DOCUMENT RESUME

ED 229 254 SE 041 456

TITLE	Toward Excellence in Science Education. Proceedings of Annual Curriculum Update Conference (June 18-23, 1982).
INSTITUTION	Iowa Univ., Iowa City. Science Education Center.
PUB DATE	82
NOTE	110p.
PUB TYPE	Collected Works - Conference Proceedings (021)
EDRS PRICE	MF01/PC05 Plus Postage.
DESCRIPTORS	Computer Oriented Programs; Concept Formation; Creativity; *Curriculum Development; Educational Improvement; *Educational Objectives; *Educational Trends; Elementary School Science; Elementary Secondary Education; Policy Formation; Relevance (Education); Science Activities; *Science Curriculum; *Science Education; *Science Instruction; Science Supervision; Secondary School Science; Teaching Methods
IDENTIFIERS	Computer Uses in Education; *Science and Society

ABSTRACT

The National Science Teachers Association (NSTA) Horizons Committee met in Iowa City (Iowa) before the 1982 Curriculum Update Conference. The committee was charged with planning a new future of science education. The thinking of the members of the Horizons Committee provided the framework for the 1982 conference. These proceedings represent a record of the thinking, deliberations, and outcomes of their efforts and, in a sense, represent a status report concerning the directions envisioned by some of the current leadership in science education. Areas and issues addressed include: aspects of a renewal in schooling and education; learning from past mistakes; status of precollege science/mathematics education; computer use in the science curriculum; activity-based curriculum projects for societal issue courses (includes a bibliographic list of activities/projects matched to science/society issues); a brief review of the Individualized Science Instructional System (ISIS); naive conceptions of science and instruction; and NSTA's 1982 Search for Excellence program. Other areas/issues considered include developing creativity as a result of science instruction; crisis in the science classroom; linking teacher behaviors to student outcomes; science educators and policy makers; teaching citizens about science/technology, relevance in science education; need for solutions for lingering problems; and supervision and teaching perspectives. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

Proceedings of Annual Curriculum Update Conference

ED229254

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Robert Yager

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

TOWARD EXCELLENCE IN SCIENCE EDUCATION

June 18-23, 1982

SE041456

Science Education Center, The University of Iowa, Iowa City, Iowa 52242

TABLE OF CONTENTS

	Page
Foreword	i
Conference Presenters & Staff	1
Program	4
Some Aspects of a Renewal in Schooling and Education in Science, Paul Brandwein	10
Growing from 'Mistakes' of the Past, Robert E. Yager	22
State of Precollege Education in Mathematics and Science, Paul DeHart Hurd	26
Using Computers in the Science Curriculum, Vincent Lunetta and Jerry Doyle	32
ISIS Program, Jan Wielert	34
Activity-Based Curriculum Projects for Societal Issue Courses, Mike Lawler	36
Naive Conceptions of Science & Instruction, Audrey B. Champagne	62
NSTA's 1982 Search for Excellence, Robert E. Yager	68
Developing Creativity as a Result of Science Instruction, John E. Penick	70
The Crisis in the Science Classroom, Robert B. Sigda	76
Linking Teaching Behaviors to Student Outcomes, David P. Butts	81
Science Educators and Policymakers, Audrey B. Champagne	86
Teaching Citizens About Science and Technology, Rodger W. Bybee	91
Toward Relevance in Science Education: Bases for Applications in the Curriculum, Vincent Lunetta and Erv Poduska	96
Needed: Solutions for Lingering Problems, Robert E. Yager	99
A Supervision Perspective, LaMoine L. Motz	103
A Teaching Perspective, Carolyn Brockway	105

Foreword

There have been many critics of science education materials, programs, actions, and goals since the so-called Golden Age of the 1960's. The early 1970's provided many voices of protest for science education; these voices became so dominant and so pronounced that political leaders all but terminated national support for science education in 1976.

In the years that followed several national studies were funded and completed that were designed to establish the status of science education, to evaluate the effectiveness of the national support that had resulted after the 1957 launching of Sputnik, to point to new directions (perhaps more effective correctives) for the 1980's.

Emerging from the assessments that were conducted during the late 1970's were clear indicators for a new kind of school science. As the ideal school science programs were described, it seemed obvious that many could already have taken significant steps in such directions. Searching the literature (especially the results of the three large NSF status studies) provided no clue concerning such programs.

This was the situation in 1981 when NSTA published Volume 3 of its What Research Says to the Science Teacher Monograph Series. This volume involved extensive descriptions of the ideal state of science teaching in the areas of elementary science, biology, physical science, inquiry, and science/technology/society. These statements became the focus for national exemplars!

The 1982 Curriculum Update Conference was planned in this setting. The NSTA Horizons Committee was scheduled to meet in Iowa City prior to the Conference. This group was charged with planning a new future for science education--perhaps one more futuristic than the Project Synthesis Ideal State descriptions. The thinking of the members of the Horizons Committee provided the framework for the 1982 Conference. These Proceedings represent a record of the thinking, the deliberations, the outcomes of the efforts of July, 1982. In a sense these Proceedings represent a status report concerning the directions envisioned by some of the current leadership in science education.

Robert E. Yager

(Where omissions occur, the conference leader for the particular session chose not to provide the summary information.)

CURRICULUM UPDATE STAFF

Presenters:

Horizons Committee

Fletcher G. Watson
24 Hastings Road
Velmont, MA 02178

Vincent N. Lunetta
Science Education Center
The University of Iowa
Iowa City, IA 52242

Audrey B. Champagne
815 Learning, Research, &
Development Center
University of Pittsburgh
3939 O'Hara Street
Pittsburgh, PA 15260

Paul DeHart Hurd
549 Hilbar Lane
Palo Alto, CA 94303

Paul F. Brandwein
Box 326
Unionville, NY 10988

Norris Harms
School of Education
University of Colorado
Campus Box 429
Boulder, CO 80309

David P. Butts
Department of Science Education
University of Georgia
Athens, GA 30602

Rodger W. Bybee
Department of Education
Carleton College
Northfield, MN 55057

E. Joseph Piel
Department of Technology & Society
College of Engineering
State University of New York
Stony Brook, NY 11794

Other Featured Presenters:

Alan McCormack
Professor of Zoology &
Science Education
University of Wyoming
Laramie, WY 82071

Mary H. Beavis
Department Chairman
Rio Grande High School
Albuquerque, NM 87105

Robert E. Yager
Science Education Center
The University of Iowa
Iowa City, IA 52242

Robert B. Sigda
12 Dunford Street
Melville, NY 11747

Bill G. Aldridge
Executive Director
National Science Teachers
Association
Washington, D.C. 20009

LaMoine Motz
Oakland Schools
Pontiac, MI 48054

Carolyn Brockway
George Washington High School
Cedar Rapids, IA 52403

Kenneth Dowling
State Department of Public Instruction
Madison, WI 53702

L. C. Flinn, Jr.
National Science Programs, Inc.
Batavia, IL 60510

Mike Geil
Science Education Center
The University of Iowa
Iowa City, IA 52242

Ethley London
Science Education Center
The University of Iowa
Iowa City, IA 52242

Other Featured Presenters: (cont'd)

James Spevak
Science Education Center
The University of Iowa
Iowa City, IA 52242

Jan Wielert
Science Education Center
The University of Iowa
Iowa City, IA 52242

Frank Affannato
Science Education Center
The University of Iowa
Iowa City, IA 52242

Daniel S. Sheldon
Associate Professor
Science Education Center
The University of Iowa
Iowa City, IA 52242

Ken Hartman
Ames High School
Ames, IA 50010

Roy Unruh
Associate Professor
Physics & Science Education
University of Northern Iowa
Cedar Falls, IA 50613

Jerry Doyle
Area Education Agency 16
305 Avenue F
Fort Madison, IA 52627

Harold L. Schoen
Professor
Secondary Education
The University of Iowa
Iowa City, IA 52242

Mike Lawler
Science Education Center
The University of Iowa
Iowa City, IA 52242

John E. Penick
Professor
Science Education Center
The University of Iowa
Iowa City, IA 52242

James A. Shymansky
Professor
Science Education Center
The University of Iowa
Iowa City, IA 52242

Donald Gurnett
Professor
Physics & Astronomy
The University of Iowa
Iowa City, IA 52242

Marilyn Zweng
Professor and Department Chairman
Secondary Education
The University of Iowa
Iowa City, IA 52242

Robert E. Lewis
Hanby School
Wilmington, DE 19810

Erv Poduska
Science Education Center
The University of Iowa
Iowa City, IA 52242

William Matthes
Associate Dean
College of Education
The University of Iowa
Iowa City, IA 52242

NSTA Officials:

Bill G. Aldridge, Executive Director
Robert E. Yager, President 1982-83
Robert B. Sigda, President-Elect

Sponsoring Groups:

LaMoine Motz, National Science Supervisors Association
Carolyn Brockway, Iowa Science Teachers Section
Kenneth Dowling, Council of State Science Supervisors

Science Education Faculty:

Robert E. Yager, Professor/Director
John E. Penick, Professor
Vincent N. Lunetta, Professor
James A. Shymansky, Professor
Edward L. Pizzini, Associate Professor
Darrell G. Phillips, Associate Professor
John T. Wilson, Associate Professor
Daniel S. Sheldon, Associate Professor
George W. Cossman, Associate Professor

PROGRAM

Sunday, July 18, 1982

TIME	SESSION	LOCATION
Noon-4:00	Arrive and check-in	Iowa House, Burge Hall, etc.
4:00 p.m.	Registration	316 VAN
6:00	Welcome, Associate Dean William Matthes, College of Education	301 VAN
6:30	Renewing Schooling & Education, Paul F. Brandwein	301 VAN
8:00	Exploring Iowa City on a Sunday Evening led by Iowa Science Teachers	

Monday, July 19, 1982

8:30 a.m.	Growing from Mistakes of the Past, Robert E. Yager	301 VAN
	The Status of School Science Education, Paul DeHart Hurd (paper to be distributed)	
9:45	Break	
10:00	Break-out Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. Using Computers in the Science Curriculum, Vincent Lunetta & Jerry Doyle	469 VAN
	D. The ISIS Program, Jan Wielert	362 VAN
11:45	Lunch	
1:00 p.m.	New View of Science: Technological & Societal Dimensions, E. Joe Piel	301 VAN
2:15	Concurrent Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. Professionalism During the 1980's, Bill G. Aldridge	469 VAN
	D. Science/Society Materials, Mike Lawler	362 VAN

PROGRAM

Monday, July 19, 1982 (cont'd)

TIME	SESSION	LOCATION
3:30	Break	
3:45	Symposium: Reflection on Issues A. Jack Gerlovich B. Marilyn Zweng C. Fletcher Watson	301 VAN
4:45	Search for Solutions, Robert E. Lewis	301 VAN
6:00	Break	
6:30	Meet Informally with Members of NSTA's Horizons Committee	Dan Sheldon Home-1300 Ashley Drive

Tuesday, July 20, 1982

8:00 a.m.	Naive Conceptions of Science & Instruction, Audrey Champagne	301 VAN
9:15	Symposium Special Implications For -	
	A. Elementary School - David P. Butts	301 VAN
	B. Middle School/Junior High - Harold L. Schoen	301 VAN
	C. High School - John E. Penick	301 VAN
10:15	Break	
10:30	Concurrent Sessions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. NSTA's 1982 Search for Excellence, Robert E. Yager	469 VAN
	D. OBIS & USMES Activities, James Spevak	362 VAN
11:45	Lunch	
1:00 p.m.	Enhancing Creativity Through Science, John E. Penick	301 VAN

PROGRAM

Tuesday, July 20, 1982 (cont'd)

TIME	SESSION	LOCATION
2:00	Concurrent Sessions	
	A. The Iowa-UPSTEP Model, John E. Penick	456 VAN
	B. Crisis in the Classroom, Robert B. Sigda	474 VAN
	C. Creativity & Science Teaching, Alan McCormack	469 VAN
	D. The IAC Program, Eric Zehr	362 VAN
3:15	Break	
3:30	Citizenship, Social Change, & Science Education, Rodger Bybee	301 VAN
4:45	Tour of Van Allen Hall & Space Laboratories, James Demro	Dubuque St. Entrance to Van Allen Hall
6:00	Dutch Treat Dinner	Iowa River Power Restaurant
8:00	Reports	
	A. NSTA Horizons Committee, Fletcher Watson, Chair	474 VAN
	B. NSTA Yearbook Committee, David P. Butts, Chair	474 VAN

Wednesday, July 21, 1982

8:15 a.m.	Linking Teacher and Student Behavior, David P. Butts	301 VAN
9:30	Break	
9:45	Break-out Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. Development of Reasoning & Teaching, Ethley London	469 VAN
	D. National Wildlife Federation's CLASS Project, Daniel S. Sheldon	362 VAN

PROGRAM

Wednesday, July 21, 1982 (cont'd)

TIME	SESSION	LOCATION
11:00	Science Educators & Policy-Makers, Audrey B. Champagne	301 VAN
11:45	What Surveys of Teachers Reveal: Reports to Congressional Leaders, Bill G. Aldridge	301 VAN
12:30	Lunch	
2:00 p.m.	Depart for Amana Colonies	
5:00	Happy Hour at Ronneburg Bier Garden	Amana Colonies
6:30	Dutch Treat Banquet	Ronneburg Restaurant
8:00	The Outer Planets Through the Eyes of Voyager, Donald Gurnett, Physics & Astronomy	Lecture Room 2, Van Allen Hall
9:30	Iowa's Night-On-The-Town	Red Stallion

Thursday, July 22, 1982

8:15 a.m.	Teaching Citizens About Science & Technology, Rodger Bybee	301 VAN
9:15	Toward Relevance in Science Education: Bases for Applications in the Curriculum, Vincent Lunetta & Erv Poduska	301 VAN
10:15	Break	
10:30	Break-Out Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. New Approaches to School Physics, Roy Unruh & Ken Hartman	469 VAN
	D. Health Education Through Science, Daniel S. Sheldon	362 VAN
12:00	Lunch	

PROGRAM

Thursday, July 22, 1982 (cont'd)

TIME	SESSION	LOCATION
1:00 p.m.	What Research Says About Success of Science Education Since 1960, James A. Shymansky	301 VAN
2:15	Break-Out Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	474 VAN
	C. Search for Excellence: Future Plans, John Penick & Bob Sigda	469 VAN
	D. Human Sciences Program, Frank Affannato & L. C. Flinn, Jr.	362 VAN
3:30	Break	
3:45	The Power of Individuals & Organizations in the Capitol, Mary H. Beavis	301 VAN
6:00	Cocktails	Robert Yager Home 330 Highland Drive
7:00	Barbeque	Robert Yager Home 330 Highland Drive

Friday, July 23, 1982

8:30 a.m.	Science Education Research & Classroom Practice, James A. Shymansky	469 VAN
9:30	Break	
9:45	Break-Out Discussions	
	A. A Teaching Perspective - Carolyn Brockway	456 VAN
	B. A Supervision Perspective - LaMoine Motz	456 VAN
	C. Excellence: A Continuing Quest, Ken Dowling	469 VAN
	D. Energy Education Modules, Mike Geil	362 VAN

PROGRAM

Friday, July 23, 1982 (cont'd)

TIME	SESSION	LOCATION
11:00	Needed: Solutions for Lingering Problems, Robert E. Yager	469 VAN
11:45	Lunch	
1:00 p.m.	The Need for Vision, Fletcher Watson	Lecture Room 2 Van Allen Hall
2:15	Certificates & Awards	Lecture Room 2 Van Allen Hall

Some Aspects of a Renewal in Schooling and Education in Science

Paul F. Brandwein
Director of Research
Harcourt Brace Jovanovich, Inc.

We need to see past the psychobabble. We are required once again--if only in a quest for sanity--to focus on our permanent agenda and direction. It is this: Schools hold up to the young and the community an habitual vision of greatness. They do this invariably through their curriculums and instructional modes.

A. The present situation looks like this:

1. We are about to reform the schools once again. If this is said in a weary tone, it is not meant to be. It is a sad tone reflecting this question: Why are schools, not communities, bearing the brunt of the criticism? In my observations over 30 years (in more than 1,000 communities over the world), it has been rare for me to find a community that does not work and a school system within that does; it is also rare to find a community which works and a school system within it that does not. School and community are locked in an ecology of achievement.[1]

We are just leaving a decade of saturation in the "basics"--narrowly conceived as skill in reading. Just ahead, once again a cry that we've "neglected" science and mathematics and the social studies (the social sciences as well), and, of course, gifted. Once again we may succumb to the "crash program"--sure to be unbalanced in curriculum and instruction, and, if we do, we shall be called to the task 20-25 years hence when once again

the communities of scholars and practitioners hear a new drummer--or mistake the loud rattle of discontent for a drum.

Careful study will show generally that 15-20% of our students do splendid work (comparing favorably with the best elsewhere), about 15-20% do respectably well, about 30-40% do passing work. And, to our dismay, 20 to 25% of our students get about 75% of the failing marks. In the latter group, 5 to 10% attend school sporadically. This is a perennial group. Are we building an intellectual and social underclass?

In the SAT's, about the same percentage of students (as in the past) continue to score in the higher ranges, the 700's. It is also true that more students than in the past two decades are found in the lower ranges, the 300's. It is also true that many more students apply for entrance to college (including populations which did not attempt it in the decades past).

All in all, the criticism of the schools (divorced from the communities which formulate policy) is flimsy. But I am persuaded that reason (even emotion) and such "facts" as are available are not to prevail. Why?

2. The world is again at one of its strange turning points: Another crisis, meaning crossroads, (as in 1855, 1890, 1912, 1929, 1957) is upon us. This time it is called the post-industrial revolution.[2] In a word, science and technology, having

replaced routine labor by muscle with machines, are now, as well, replacing routine labor by neurons with newer machines. Machine-assisted intellect is affecting cultural, social, and economic well-being. And, of course, the schools are willy-nilly to solve the problem.

The problem: The central person in a post-industrial revolution is the literate (synonym: educated) person. But these are not the years of alchemy; training in science and mathematics required for a new age--any new age--means also decent grounding in languages in the science of society, and in the humanities. For modern advance in science requires not only physicists, chemists, biologists, geologists, but also enthicists. In turn, the social scientist, the historian, will be obligated to acquire a thorough grounding (among other things) in science and mathematics. The world may indeed become one in another half-century. Science and technology are not only of great benefit, but their misapplication terrorizes. To fail to apply modern science and technology with wisdom--whether in the uses of the gene or atom--may consign us to the past. And, if we survive, our age may well be placed in the category of pre-history (the age of the barbarian) and not in the cadenced ancient history which included certain kinds of civility and comity.

B. If indeed the world does take the sharp turn--even detour--it seems to be taking, the thrust of the reform in schooling and education will be obliged to consider changes in curriculum and instruction.

This may seem obvious--even banal--but when one considers the general absence of "true" curriculum reform (textbooks, which are instructional materials, are often used incorrectly as curricular innovations); when one considers that the lecture is the general mode of instruction (no matter the heterogenity or age-placement of the class), reform in curriculum and instruction is clearly necessary. The thrust in reform might be along these lines:

1. It must look to the schooling (a word on education later) of all the young--not only those who were fortunate in their choice of parents, or the special moment in history which required their special talents.

2. It will be required to be a whole in curriculum and instruction.

Students of trends in the present and immediate future in the post-industrial era predict a work situation where jobs in manufacturing and agriculture (increasingly mechanized and computerized) will be drastically reduced and jobs in the services and management will increase. Thus the general prediction is that by 1990-2000 some 10-20% might well be in manufacturing and 80-80% in services (i.e., professions, transportation, processing of all sorts. Professions related to schooling and education will be on the increase, for the educated person is central to a post-industrial era). But the nature of specific job markets will change, and newly-formed educational programs (not ncecessarily in schooling) will need to be devised. That is to say, schooling has--and may continue to be--centered in

planned programs ("instructed learning," Bruner's phrase) while education may well rest in newly-devised devices (content, method) depending on new devices as yet unkown. In an age where machine-assisted intellect is central, certain jobs may well "disappear;" re-education (not re-schooling) will be a commonplace.

It is further to say that the phrase "equality of opportunity for equal achievement" will require new modes of application. Surely there is no need to badger the phrase or its intent; in a democracy variety in personality and talent is a guarantee of basic freedoms; hence, equal opportunity for all--however varied. It is, however, to say that once equal opportunity is afforded, difference in rate of progress of achievement, of choice in destination, of future paths of schooling and/or education will come to the fore. It is to say that in curriculum and instruction, as well as in schooling and education there is nothing so unequal as the equal treatment of unequals. This implies a higher ethic in equal opportunity, namely, special opportunity for the varieties of ability which make the human environment so rich, so full in resources.

Nonetheless, in a post-industrial era, science, social studies, mathematics, language--metaphorical right-brained and left-brained processing are central.

We are obliged then to look to strengthened-perhaps different--curricular and instructional modes; we need in short to look to the whole.

Teachers contend not only with meaninglessness and mindlessness, not only with ignorance and narcissism, but also with the mortifying <u>sameness</u> of treatment of the young (misinter-

preted as equality of oppotunity). A curriculum, to repeat, is not found in textbooks--or a sequence of textbooks--one for each grade. In the end, curriculum is a reduction of complexity of the culture; the young are to have a roadmap of the culture so that their first years have a degree of surefootedness. Times, and the culture, will change soon enough.

A curriculum looks to the domains of experience[1] and realness of meaning central to our culture and the concepts, values, and skills derived from them. As Phenix[3] describes them, these realms of meaning are:

symbolics	(i.e., discursive and non-cursive language)
synoptics	(i.e., history, philosophy, religion) (self-concept)
empirics	(empirical area--science, certain areas in the social sciences, and certain areas of mathematics)
esthetics	(disciplines of form and self-expression)
ethics	(disciplines addressing "right" and "wrong," "good and "bad")

Curriculum and instruction in any discipline (or, if you wish, all disciplines) draw their concepts, values, and skills as well as their definition, constraints, and limitations from these realms of meaning and their derived domains of experience.

A curriculum, a fairly stable document, is not subject to whim, fad, to attack by special interest groups, or to changing

subject matter per se--for these do not alter the basic concepts, values, and skills useful to a culture thriving (not just surviving) in the 21st century (whether "stable" or in insurgency). They may alter a skill (i.e., the computer), but this change affects--at least for the central thrust--change in instruction, not concepts, values, and skills central to a curriculum. To reemphasize, a textbook and a teacher's guidebook do not constitute a curriculum; they are instruments of instruction.

A curriculum in any discipline would, by way of example, characteristically embrace, or abide by, these constraints (among others):

1. Seek a clear definition of the domain of experience. For example, note this definition of science (modified from one by George Gaylord Simpson):

> Science is an exploration of the material universe; in order to seek orderly explanations (generalizable knowledge) of objects and events; but these explanations must be testable.*

2. The definition insists that speculation, hypothesis, theories, facts, data--any statement--be verifiable or falsifiable. If one or the above cannot be falsifiable (e.g., statements, contributions, constructions in the arts, including literature and religion), it may not be introduced in the corpus of the discipline. The constructs--not accessible to the domain of experience say, in science--may of course (at least where

---

* I do not find such systematic assertions applicable to other disciplines--; but this may be due to my ignorance and deficient research.

schooling is concerned) be accessible to the concepts, values, and skills we call social studies, or the humanities. We need definitions of other disciplines, particularly the social studies and/or social sciences--for surely the empirical and social disciplines are twins.

3. Would maintain up-to-dateness (that is, constant renewal of the curriculum) by seeking out new concepts, values, skills--accepted by the culture.

Other rapidly changeable areas--invention, technology, data, facts--properly belong to the readily adaptable area of instructional devices and materials--for these are in the service of the concepts, values, and skills marshalled in the curriculum. For a curriculum is a document of the generalizable knowledge the culture embraces.

By way of example--the concept: The organism is the product of heredity and environment and is generalizable. But "bloodlines," family, society, culture, sire, dam, blood relationships, homunculi, seed (in its hereditary sense), determiners, chromosomes, genes, DNA, are elements of content and terminology--changeable even within a decade or generation. The latter are properly parts of the historical treatment in instructional materials--such as textbooks, laboratory manuals, workbooks, cassettes, computer discs, etc.

On the other hand, instruction, hearkening as it does constantly to the curriculum--ever obligatory--looks both to the student and the classroom (where the teacher's behavior is discretionary) as is the teacher's choice of content and process. For students are recognizably different not only in mode and manner of learning (so-called modalities), but also in background and ability. Accordingly, teachers are obligated not only to vary level of treatment, but also to select appropriate content, not to say methods and processes that are designed to bring forth the responses which signal a student's parti-

cipation in the lesson. On this, please see the theories of teaching (instructed learning) and curriculum appended (note 1). Thus it seems that where instruction is concerned, these constraints, among others, require consideration:

a. In the coming decades, those who have learned to learn, have learned how to learn, and have learned what, how, and to choose from whom to learn with a degree of independence required, will have greater opportunity to contribute and benefit from the socio-scientific and scientific-technological age we call the post-industrial era. The teacher's superordinate task--and his or her love of student and subject both--has the singular aim of helping the loved one depart (armed against the future) not to hold students in bondage. In short, the lecture method, and the high effort of teachers over a twelve-year period--<u>at the beginning</u>-- must leave off to increasing effort by the student at the end (the senior high school years) when and where the student takes over most of the effort and work of learning. The teacher is then guide to the archives, not their guardian. The model is then not one where the lecture is dominant in junior and senior schooling (over 12 years it might conceivably be reduced to 25% of the class period), but one in which the student increasingly achieves mastery of his or her own fate as a learner. Thus over 12 years the instructional mode might shift thus:

Levels	Teacher's Initiative	Student's Initiative
K-3	70-80%	20-30%
4-6	50%	50%
7-9	40%	60%
10-12	20-30%	70-80%

If you wish an extended description of this "maturity-independence model," see Chapters 4-5.[1]

b. In the junior and senior high schooling, there is the possibility that each student may be given the opportunity to do one (1) experimental study, as distinguished from the necessary exercises, which offers students experience only with the history (therefore repetion) of famous investigations or studies.

c. In my view, which I shall not defend at all costs, or in all instances, our present teaching emphasizes problem-doing, not problem solving. A general view of research would indicate that mental activity is not generally directed by problems but by objects and events. If the object or event is not recognized, a problem is generally not recognized. And if a governing concept is not available, a problem and subserving hypotheses cannot be adequately stated. The fact remains that ignorance is not a base for discovery, but problem solvers depend on acquiring "masses of structurally organized knowledge. Such knowledge is made up of content principles, not heuristic ones." (See Gagne.[4])

Teachers, to be sure, have the skills of instructors in presenting subject matter, but teachers are more than instructors. The latter are no larger than their subject matter; teachers are as large as life. Teachers insist on authentic activity, reflection, and reconstruction of concepts, values, and skills. They encourage the critical, solitary, even contrary thought, provided it is based on a skillful grasp of information, careful analysis and synthesis of elements, and in the end--its application to a revision of thought and action. In short, critical thinking. Where the act of teaching is a flow between student and teacher, where the student expects to respond and is prepared to re-

spond, the atmosphere and effectiveness of the teaching act is entirely different from that in which the teacher is the sole actor and the students are passive, not interactive and respondent. The heuristic act enters upon a discipline of responsible consent and dissent; it is not the gymnastic act of seeking the expected response nurtured by the lecture or the exercise in problem-doing, however well conceived.

We are not in a paltry crisis--in which a change in textbooks or eponyms suffices. We are entering a newer and different world in which a change in behavior is called for. As teachers, we enter the minds of others; thus we live in eternity. We help others live better lives, thus teaching remains a mercy. Who else but those who have given their lives to producing changes in others can--or should--now take on the necessary change in their own personal behavior in the classroom. We stand not only on the shoulders of others--but if we but look, we should realize--with effective surprise--that we stand on our own.

1. Paul F. Brandwein — MEMORANDUM: ON RENEWING SCHOOLING AND EDUCATION. New York: Harcourt Brace Jovanovich, 1981.

2. Daniel Bell — THE COMING POST-INDUSTRIAL SOCIETY: A VENTURE IN SOCIAL FORECASTING. New York: Basic Books, 1973.

3. Philip H. Phenix — THE REALMS OF MEANING: A PHILOSOPHY OF THE CURRICULUM FOR GENERAL EDUCATION. New York: McGraw-Hill, 1964.

4. Robert M. Gagne — THE CONDITIONS OF LEARNING. New York: Holt, Rinehart & Winston, 1965

Growing from 'Mistakes' of the Past

Robert E. Yager
Science Education Center
University of Iowa

It is always easy to look back and to identify mistakes. Hindsight is always easier than foresight!! However, we can sometimes learn from our hindsight and thereby improve our foresight.

The past twenty-five years have been exciting ones in science education. More than two billion dollars have been expended to improve science education. Such a goal was supported by the American public as a response to the launching of the Soviet Sputnik in 1957. Over three million dollars was spent for developing new course materials; similar funds were provided by NSF to support in-service teacher education activities. Most of this support vanished -- just twenty years later. Funds for six active curricula projects were reduced as the efforts were questioned. In 1976 all funds for direct support of teacher education were curtailed. What went wrong? The five years that have followed have resulted in one of the most extensive periods of assessment ever undertaken by a nation -- certainly the first in U. S. history.

Many persons recognized specific problems with our efforts during the preceding two decades prior to this assessment. A look at these perceived errors may help as we plan for the next twenty years.

Many see that the original postulate used by the PSSC architects and most national "curriculum" projects that followed to be in error. This postulate stated: When science is taught in a way it is known to scientists, it will be inherently interesting to all students. It is easy to look at enrollment trends and to conclude that the postulate was not true. Certainly we need leading scientists at work defining the unifying themes, the major organizers, the central ideas. The omission of people, technology, society

from the national curriculum efforts may not have been wise.

All of the curriculum efforts included the idea that science should be taught as a narrative of inquiry instead of a rhetoric of conclusions. Many called for at least half of the effort in school science to be placed upon teaching inquiry. And yet, in 1962 Hurd concluded that inquiry was not being taught -- could not be taught -- or that students could not learn it. Some feel that the inquiry skills identified were too sophisticated; the ideas and the skills could not be transferred to daily living.

A third problem deals with the lack of a curriculum sequence. In fairness, the NSF initiative was never focused on "curriculum" planning. Instead, the section in charge of funding curriculum efforts was called the "Course Content Improvement Section." Perhaps some of the three million dollars could have gone to studies of and experiments with the K-12 science curriculum.

During the 1960's we assumed that one program would fit all students. We assumed that a "perfect" course could be developed. Bruner posited another postulate that we all accepted: Any student can learn any subject in some intellectually honest form regardless of his/her stage of development. This idea certainly stimulated us to structure content in a way that it was true to the discipline; surely it would be appropriate in terms of difficulty for all students at a given age level.

Another mistake was our willingness to ignore instructional goals. Many of the scientific community were suspect of goals -- often they were confused with content goals, especially the unifying themes for a given discipline. One curriculum developer when asked about goals was said to have referred the person to the textbook for a look at what the goals "obviously were." It is now apparent that goals should be stated in terms of essential behaviors which we would like to see exhibited in students following instruction.

During our Golden Age (1960's) we never progressed beyond teaching science for groups with the teacher as director. We did little for students of varying abilities and interests. We did not experiment with instruction from any view except one with the teacher as classroom director.

We tended to view science in isolation from all other aspects of the curriculum. We gave electronics to industrial arts, health to physical education, nutrition to home economics, horticulture to agriculture. We wanted to deal only with real science, pure science, "white coat" science. We certainly did not want to use other experiences in the community, home, or television in presenting "our" science. We assumed that science took place only in our laboratories in the assigned fifty-five minute period.

Science has been too much tied to a course, textbook, and discipline model. We never thought beyond a course which must have a textbook which, in turn, must reflect a given discipline. The restriction of our thinking to "courses" was a mistake. Surely, to assume that the only product of a course improvement effort (or surely a curriculum development) should be a textbook is ridiculous. Thinking of science as an experience with a given discipline of science is also very limiting. We were enamored with practicing scientists and their willingness to translate new discoveries into courses for K-12 students.

We involved teachers in the curriculum developments. However, most were not viewed as central; they merely provided a sounding board and a means of trial for the new materials. In addition, the three hundred million dollars spent for improving teachers was largely restricted for improving subject matter (discipline) competency of teachers. Teachers went to a college campus to learn some specific content which presumably in some miraculous way could be used in the K-12 classroom. Usually it was! The information from institute courses was often added to K-12 science classes. After all, what does a teacher do with new knowledge is he/she doesn't

"give" it back to students??

Another mistake with the efforts for the 1957-76 period was the emphasis upon the development of cognitive skills only. Little was done to consider the other aspects of student growth. Surely science--with its relevance to current society--should have much to offer in a variety of domains.

The goal of making science popular for students was a worthy one. However, we started with several wrong assumptions; we never bothered to check them; we waited twenty years to note that the newer materials were not "inherently" interesting. We are just now ready to re-examine the issue of what students can learn, what they should learn, and what we can and should do about the situation.

It has been a fascinating quarter of a century in science education. The great attention and support we received may have provided us with the experience and know-how to make the next twenty-five years even more exciting--especially if we are willing to learn from our mistakes.

State of Precollege Education in Mathematics and Science

Paul DeHart Hurd (Emeritus)
Stanford University

In recent months the scientific and engineering communities have been exploring ways to maintain the vigor of research and technological innovation in the United States. In the course of these discussions several disturbing problems have emerged relative to the teaching of precollege science and mathematics. For nearly a decade science enrollments in high schools have been decreasing and students are demotivated to study science. In mathematics students are taking more semesters of courses, but show an overall decline in achievement. For both science and mathematics courses there is a growing shortage of qualified teachers. If a reasonable degree of scientific and technological literacy is an expected outcome of a high school education, it is not being achieved (1).

The Quality of Science and Mathematics Learning

Since 1960 the average achievement scores in science and mathematics on a variety of test instruments have shown a steady decline (2, 3). Scores on the Scholastic Aptitude Test (SAT), widely used by colleges and universities for making admissions decisions, provide evidence of the decline in mathematics. The mean score in mathematics has dropped from 502 in 1963 to 466 in 1980. The proportion of students scoring above 700 (possible 800) on the SAT mathematics test declined 15 percent over an eight-year period, 1967-1975. During the same interval students scoring below 300 on the mathematics section increased 38 percent. Data from the American College Testing Program for the years 1965-1966 and 1973-1974 show that mean scores on the natural science test remained stable.

In 1969 the Education Commission of the States began a nationwide program to assess the educational attainment of young Americans in certain subject areas. The program, known as the National Assessment of Educational Progress (NAEP), gathers census-like data to measure growth or decline in knowledge, skills, understanding, and attitudes of precollege students. Science measures were made in 1969-1970, 1972-1973, and 1976-1977 on age samples of 9-, 13-, and 17-year olds. The mean score of correct responses in science has declined with each assessment, the greatest decline occurring in the 1970-1973 period. The decline between 1969 and 1977 is least for 9-year-olds and greatest for 17-year-olds. Each successive test shows a greater decline in scores on physical science topics than for biology where there was a slight increase in knowledge for 9- and 13-year-olds (4).

America in Transition

The ills of schools broadly reflect those of society as well as shifts in the culture. About half of the decline in school achievement across academic subjects since 1970 appears to be due to social and cultural factors (5). In the late 1960s, scholars in the social sciences reporting on changes in America described conditions as a "cultural mutation," "a watershed period," the approach of a "post-industrial society," the "emergence of a new technological age" and the rise of "a learning society." It was about this time when a few economists began to regard the utilization of knowledge, especially scientific and technological, as a productive factor rather than a consumer item (6, 7). The study of knowledge production, diffusion, and utilization is in itself an emerging discipline along with information processing. An increasing percent of the work force is connected to the retrieval, processing, and transmission of information. The role of microelectronics for enhancing the intellectual capacity of the human mind may well add a new "basic" to education. Notions about the aims, substance, and quality of education in the United States must

certainly respect the changes taking place throughout all of life. Some teachers think students have already noted the gap between schooling and the real world and are taking a rest until educational conditions improve.

When parents feel there is something amiss with schooling they protest with a cry of "back to basics," "no frills," or "teach fundamentals." Parents generally define "basics" to include respect for authority, good manners, less permissiveness in schools, home assignments and classroom discipline. "Back to basics" is not a true educational issue; no one questions the value of reading, arithmetic, and writing. A more serious question to many educators is the overemphasis on reading and arithmetic in the elementary school and the neglect of science, art, music, and the social studies. Reasoning, responsibility, and reverence for democratic values are also "Rs" widely neglected (8). The central issue is that students enter high school deficient in reading, writing, and mathematical skills, as well as in knowledge about science, civil rights, politics, music and literature (9). The decline in academic achievement is across all subjects. The problem is to restructure the educational system to provide checkpoints at several grade levels to ascertain learning deficiencies and then to establish correctives.

Some Constraints Influencing Science and Mathematics Education (10)

The United States lacks national goals, public policies, or an agenda to focus discussion and debate in the reconstruction of science and mathematics education. As a basis for policy, the need for a high level of scientific, technological, and computer literacy for all citizens is most often identified. If this is to be a goal of science and mathematics education at the precollege level, parents, teachers, and school administrators must first recognize its significance.

The School Curriculum

Doubts exist as to whether the commonly offered science and mathematics

courses in high school are of value to the general citizen, at least in their present form. Students regard upper level mathematics, physics, and chemistry courses preprofessional subjects for those who wish to become engineers, mathematicians, or scientists (11). For science subjects the issue is: What knowledge acquired in the past 100 years from various science disciplines should be selected to provide 160-clock hours of instruction for a high school course? Not only should this knowledge be scientifically valid, but it should also satisfy the requirements of cultural validity.

Throughout the past decade half the colleges and universities in the United States have developed courses or programs designed to interrelate science, technology, and cultural imperatives (12). Courses are offered with such titles as "science-technology-society," "science-technology-values," "human biology," "human ecology," "science and ethics" and other names representing themes on science and the culture (13). At no other time in modern history can one find a science curriculum adjustment in colleges and universities of this extent. These are all courses designed to make it possible for citizens to participate more wisely in the affairs of a science/technology based society (14). However, one seldom finds a high school science or mathematics course taught in the context and with the aim of effective citizenship.

Summary

Among the developed and developing countries throughout the world there is widespread recognition of the importance of science and technology in fostering human well-being, and in meeting the economic and political demands of living in the twentieth century. For the United States to meet similar goals will require a knowledgeable and concerned public as well as specialists in the generation of scientific knowledge and technological innovations. The commitment of precollege education in the sciences and technology must be to the general public. There is a vast amount of scientific information that should be a part of human experience, not only for the intellectual insights it provides to the

individual, but for its usefulness in advancing human welfare and the nation. To achieve a science education with these ends will require the cooperative endeavors of parents, scientists, engineers, government officials, school administrators, media specialists, and experts in the social sciences, and all others with a positive vision of America's future. These people will need to lay the groundwork for a school curriculum in the sciences and technology that has both scientific and cultural validity.

References and Notes

1. National Assessment of Educational Progress (NAEP). Attitudes Toward Science. Denver: Education Commission of the States. 1979. p.5.

2. Jones, Lyle V. "Achievement test scores in mathematics and science." Science. Vol 213, pp. 412-416. (24 July 1981).

3. The National Research Council. The State of School Science. Washington, D.C.: National Research Council. 1979.

4. National Assessment of Educational Progress. Three Assessments of Science, 1969-1977: Technical Summary. Washington, D.C.: National Center for Education Statistics. 1979. pp. 11-14.

5. The College Board News. 6:1:1-3. (September, 1977).

6. Machlup, F. The Production and Distribution of Knowledge in the United States. Princeton: Princeton University Press. 1962.

7. Schultz, T.W. Investing in People: The Economics of Population Quality. Berkeley: University of California Press. 1981.

8. Hurd, P.D. "Back-to-basics: a critical juncture in biology education." The American Biology Teacher. 14:3:181. (March, 1979).

9. NAEP Newsletter. 6:9 (December 1973); 11:1 (February, 1978); 14:3 (Fall, 1981); 14:4 (Winter, 81-82) and 15:1 (Spring, 1982).

10. Statements in this section are a synthesis of the most frequently mentioned issues and problems on precollege science and mathematics education appearing in science, engineering, and educational journals and public press.

11. National Council of Teachers of School Mathematics. Priorities in School Mathematics. Reston, Virginia: National Council of Teachers of Mathematics. 1981

12. American Association for the Advancement of Science. EVIST Resource Directory. Washington, D.C.: AAAS, 1978.

13. Science, Technology, and Society. Curriculum Newsletter of the Lehigh University STS Program. Bethlehem, Penn.: Issued serially.

14. Bulletin of Science, Technology and Society. Fairfax Park, N.Y.: Pergamon Press. Volume I, No. 1. 1981.

Using Computers in the Science Curriculum

Vincent Lunetta
Science Education Center
University of Iowa

Jerry Doyle
Area Education Agency #16
Fort Madison, Iowa

Potential uses of microcomputers in the science classroom of the 1980's and 1990's were the focus of this session. Examples of different types of applications by science teachers were reviewed and common problems of purchasing hardware and software were discussed.

Compter assisted instruction (CAI) is one of three major areas of computer application in science education. Drill and practice is the most common form of CAI and is used to provide instruction in terminology, computation, and other essential skills. Direct instruction to a student can be provided through the tutorial mode of CAI. Simulations can be used to demonstrate experiments that are difficult to perform.

The microcomputer can be used as a tool for student homework and research. Important applications in the realm of problem solving, computational aid, experiment analysis, laboratory instrumentation, and the analysis of pooled data from the laboratory were discussed.

Another final global area of application of microcomputers in the science classroom is as a teacher's aide. The microcomputer can greatly simplify the tasks of testing and evaluation, handout preparation, course management, and information storage.

The importance of cost, proximity of repair center, and availablity of software was stressed in selecting microcomputer hardware. Guidelines for evaluating software were also analyzed.

The motivation and learning aspects of microcomputers in the science classroom must be carefully considered by teachers who are sensitive to student needs and capabilities if optimum use of this new instructional medium is to be realized.

In conclusion, recommendations were discussed which included the role of NSTA in furthering the distribution of information about the uses of microcomputers for science teachers.

ISIS PROGRAM

Jan S. Wielert
Science Education Center, University of Iowa

Throughout the Curriculum Update Conference calls were made for fundamental changes in both how science is taught and what science is taught in our public schools. Two decades of the "new" science do not seem to have improved the attitude of the public towards the importance of science in public education. To advocate more of the same content-emphasis in science programs today is to accept more of the indifference we see around us. Participants were urged by the speakers to teach a science which speaks more directly to the needs, interests, and abilities of all students. The ISIS (Individualized Science Instructional System) program offers a wealth of opportunity for meeting these goals.

ISIS consists of a series of about forty self-contained modules which cover a wide range of topics from the various science disciplines. Implementation of the ISIS program may amount to adding one module to an existing science program or it may involve the development of a semester or one-year course composed of several ISIS modules. Sufficient variety exists to make either extreme possible.

Individual modules are subdivided into Core, Advanced, and Excursion activities, making individualization (or personalization) of the learning experience easy. Reading levels seem to cluster around the 7.0 level. While this program was primarily designed for the middle school market, success has been reported using this program for low-ability high school students.[1] Most modules are slanted toward topics which are potentially interesting to many students. Some module titles are: Birth & Growth,

[1]"Science and Life: A Successful Mainstreaming Program in Secondary Science" by Jan S. Wielert, ms accepted for publication in Teaching Exceptional Children.

Human Reproduction, Physics of Sport, Heart Attack, and Ways We Learn. There seem to be two types of science teachers - those who have not seen ISIS and those who really like it!

Activity-Based Curriculum Projects for Societal Issue Courses

Mike Lawler
Science Education Center
University of Iowa

The current national emphasis on societal issues as an integral part of secondary science has led educators to seek assistance in the identification of activities related to specific district-selected issues. To facilitate the development of such courses, the Iowa-ASSIST office evaluated current curriculum projects and materials to produce a bibliographic list of science activities matched with science and society issues. These materials did not include textbooks or traditional guides. An issue-centered curriculum suggested direct student involvement in activities that could provide them with background or understanding of the complexity of decision-making about any societal issue. Therefore, activity-based projects and simulations were reviewed and compiled on a master list. Other considerations included: allowances for different developmental levels of reasoning; versatility of materials; appropriateness of source material and content information; opportunity for problem-solving and decision-making about human-centered issues; and career awareness. The final list is arranged by issue topics. Under each issue activities are listed to choose from to meet individual school district needs. It is meant to be a descriptive bibliography and not a prescriptive plan. The list is available from Project ASSIST. To preview materials school districts are encouraged to contact local science supervisors, Area Education Agency personnel, or publisher representatives. Additions are made as new materials appropriate to an activity-centered curriculum become available.

NEW CURRICULUM PROJECTS

Health Activities Project (HAP)

Developer: Robert Knott
Lawrence Hall of Science
University of California
Berkeley, CA 94720
415/642-3676

Publisher: Hubbard
P.O. Box 104
Northbrook, IL 60062
800/323-8368

Human Science Program (HSP)

Developer: Norris Ross
Biological Science Curriculum Study
P.O. Box 930
Boulder, CO 80302
303/666-6558

Publisher: National Science Programs, Inc.
P.O. Box 41
908 West Wilson Street
Batavia, IL 60510
312/879-6900

Individualized Science Instructional System (ISIS)

Developer: Ernest Burkman
Florida State University
College of Education
514 North Monroe Street
Tallahassee, FL 32301

Publisher: Ginn and Company
P.O. Box 2649
Columbus, OH 43216
614/253-8661

Outdoor Biology Instructional Strategies (OBIS)

Developer: Robert Knott
Lawrence Hall of Science
University of California
Berkeley, CA 94720
415/642-3679

Publisher: Delta Education
Box M
Nashua, NH 03061
603/889-8899

Unified Science and Mathematics for Elementary (USMES)

Developer: Earl L. Lomon
Education Development Center
55 Chapel Street
Newton, MA 02160
617/969-7100

Publisher: Moore Publishing Company
P.O. Box 3036
West Durham Station
Durham, NC 27705
919/286-2250

Interdisciplinary Approaches to Chemistry (IAC)

Developer: Marjorie H. Gardner
Department of Chemistry
University of Maryland
College Park, MD 20740

Publisher: Harper & Row Publishers, Inc.
New York, NY

Siscon-in-Schools Project

Developer: Joan Solomon
School of St. David & St. Katharine
Hillfield Avenue
London N8
England

Science in Society (SCINSOC) Project

Developer: John Lewis
Malvern College
Malvern
Worcestershire
WR14 3DF
068-45-61413

Creative Role Playing Experiences in Science and Technology (CREST)
Address: 855 Broadway
Boulder, CO 80302
303/492-8152

Science 5/13 (SC 5/13)
Address: MacDonald Education
850 Seventh Avenue
New York, NY 10019

National Dairy Council (NDC)
Address: 6300 N. River Road
Rosemont, IL 60018
312/696-1020

Project Learning Tree (PLT)
Address: The American Forest Institute, Inc.
1619 Massachusetts Avenue, NW
Washington, DC 20036

Acid Precipitation Awareness Program (APAP)
Address: Harriett Stubbs
Independent School District #197
1037 Bidwell Street
West St. Paul, MN 55118

Mount St. Helen's Curriculum Materials Project
Address: Educational Services
The Columbian
P.O. Box 180
Vancouver, WA 98666

Publisher/Program	Activities/Assignments
CREST	"The Rock that Burns: The Oil Shale Controversy" "Your Place in the Sun: Solar Access Law Controversy" "It is Only a Pipe Dream?: The Coal Slurry"
HAP	"Skin Temperature" (Heat traps, The Great Heat Escape, Out in the Cold, Map Your Temperature)
HSP	KK308 The Solar Merry Go Round KK309 Sunspots CC338 Wind Power/Person Power CC342 Changing Coal
SCINSOC	"Energy" (Alternative sources of energy)
OBIS	"Environmental Sun Prints"
IAC	"Form and Function" (Hydro carbons) "Communities of Molecules" (Electro Chemistry)

Publisher/Program	Activities/Assignments
CREST	"Hard Knocks: Product Liability and the Football Helmet Safety Controversy:
SC5/13	"Children & Plastics"
USMES	"Soft Drink Design" "Advertising" "Consumer Research" "Mass Communications"
ISIS	"Buying and Selling"
HSP	FF340 "Fabric Flammability Inspection" FF331 "Hairy Investigations" II311 "Scrub A Dub Dub" FF328 "Cigarette Advertising" FF330 "Fooling the Senses with Food Substitutes" FF342 "The Modern Medicine Show" KK326 "Surveys, Samples, and Schools" II320 "The Automobile"
SCINSOC	"Industry Organization and Obligation" (Social responsibility of industry)
Food . . . Your Choice (NDC)	Level 4 - "Home Economics" (Activities 16-23)

Publisher/Program	Activities/Assignments
HSP	II325 "Automatic Controls" II324 "Protecting Property" II312 "Computers" CC315 "Biofeedback"
SCINSOC	"Looking to the Future"

Publisher/Program	Activities/Assignments
USMES	"Advertising"
HAP	"Breathing Fitness" "Skin Temperature" "Personal Health Decisions" (Change a Habit) "Action/Reaction"
HSP	FF310 "Coffee and Me" FF311 "Smoking and You" FF312 "Working Lungs" FF326 "Drugs: What Do You Think" FF328 "Cigarette Advertising" FF341 "Testing Breath for Alcohol" FF348 "Where Can You Get Help" CC308 "Goldfish and Drugs"
ISIS	"Cells and Cancer"
SCINSOC	"Diseases and the Doctor" (Drug and Alcohol Dependence)
IAC	"Form and Function" (Drugs: From Aspirin to Hallincionogens)

Publisher/Program	Activities/Assignments
SC5/13	"Science from Toys"
SCINSOC	"Science and Social Development" "Looking to the Future"
USMES	"Designing for Human Proportions"
CREST	"Exhaustive Measures: Auto Emission Standards"
ISIS	"Know Your Car" "Household Energy" "House Power"
HSP	11323 "Power of Humans, Horses, and other Machines" 11319 "Kidney Machines" 11317 "Engines"
IAC	"Communities of Molecules" (Solutions; changes in energy)

Publisher/Program	Activities/Assignments
HSP	CC320 "Death" KK322 "How Old are They?" KK325 "The Very Different Ones" FF345 "Death and Disposal" FF344 "How Long Do People Live?" FF338 "Life or Death" FF337 "Geography of Life and Death" CC310 "Who Survives?"
SCINSOC	"Medicine and Care" (Care of Elderly, Care of Dying)

Publisher/Program	Activities/Assignments
CREST	"Is it Only a Pipe Dream?: The Coal Slurry" "The Rock That Burns: The Oil Shale Controversy"
ISIS	"Fossil Fuels"
SCINSOC	"Energy" (Alternative sources of energy) "Mineral Resources" (Reclamation and Recycling) "Industry: Organization and Obligation" (Oil pollution of the seas)
HSP	CC341 Oil Burn CC342 Changing Coal CC338 Wind Power/Person Power
IAC	"Communities of Molecules" (Changes in Energy)

Publisher/Program	Activities/Assignments
CREST	"Designer Genes"
ISIS	"Generation Link" "Birth and Growth"
SCINSOC	"Population and Health" (Sex and Society; Control of birth rate; Responsible Parenthood)
HSP	FF333 "Venereal Disease" FF307 "Breaking Unhealthy Habits" 1975 Experimental Modules "Reproduction"
HAP	"Growth Trends"

Publisher/Program	Activities/Assignments
HAP	"Heart Fitness" "Personal Health Decisions" (Stress management) "Your Heart in Action"
ISIS	"Heart Attack"
SCINSOC	"Diseases and the Doctor" (What is Heart Disease?)
HSP	FF346 "Emergency Care in Your City" FF302 "Is Your Family Tree Healthy" FF303 "Blood Pressure" FF304 "Blood Tests and Exams" FF305 "Rhythms of a Healthy Heart"

Publisher/Program	Activities/Assignments
SCINSOC	"Diseases and the Doctor" (Disorders of the mind) "Medicine and Care (Bereavement; Suicide)
HAP	"Personal Health Decisions" (Change a habit, on the spot)
HSP	FF308 "Can you Achieve A Natural High" FF322 "Aloneness Can Be Positive" FF323 "Expressions of Loneliness FF324 "Send a Person to Coventry" FF325 "My Life: Who Decides?" CC316 "Positive Mail" CC317 "The Phantom Toll booth" CC318 "Me Now, Me Then, Me When" FF327 "Stress: How Do You Cope" CC319 "Divorce" CC320 "Death" CC326 "Fads"
USMES	"Using Free Time"

Publisher/Program	Activities/Assignments
ISIS	"Stormy Weather"
SCINSOC	"Diseases and the Doctor" (Problems of Health in the Tropic)
USMES	"Weather Predictions"
HSP	KK342 "The Storm" KK341 "Do Dew Drops Drop?" KK340 "The Weather According to Granny Oakes" KK338 "The Rainmakers" KK339 "Weather Music"
CREST	"Rainy Day Blues: The Acid Rain Controversy"
APAP	"Acid Precipitation" "Six Million Dollar Fish" "What Have They Done to the Rain?" "p(H)otential for Hydrogen"

Publisher/Program	Activities/Assignments
SCINSOC	"Science and Social Development" "Nature of Science"
SISCON	"Man and Nature" "How can we be sure" "Evolution" "Space, Cosmology, Fantasy"
HSP	KK340 "Weather According to Granny Oakes" KK336 "Heavenly Motion" KK337 "Magic Motion" KK331 "Four Views of Mars" KK311 "The Star Gazers" KK310 "What do the Stars Know?" KK305 "Origin Stories" KK304 "RosettaII" KK303 "Counting with Carbon" KK302 "Time Travel Into the Paleozoic" KK301 "Strange Fossil" CC347 "Piecing it Together"
ISIS	"Using the Skies"

Publisher/Program	Activities/Assignments
CREST	"Hot Rods"
ISIS	"Fossil Fuels" "Radiation" (trial ed.) "Actions and Reactions"
SCINSOC	"Energy"
HAP	"Environmental Health and Safety" (Fallout)
SISCON	"The Atomic Bomb" (Science at War)
IAC	"Reactions and Reason" "The Heart of Matter"

Publisher/Program	Activities/Assignments
USMES	"Eating in School "Soft Drink Design"
ISIS	"Gut Reactions" "Let's Eat"
HSP	FF315 "Looking into the Stomach" 11303 "Food Preservation" CC343 "Calories, Calories" CC336 "Cookie Chemistry" CC313 "Changing Milk" CC314 "Changing the Recipe" FF330 "Fooling the Senses with Food Subs" FF329 "Your School Cafeteria: A Case Study" FF316 "Sensible Reducing and Weight Control"
SINSOC	"Food"
Food . . . Your Choice (NDC)	Level 4 "Home Economics" (Activities 1-15) "Health" (total)
HAP	"Nutrition/Dental Health" Lunchtime, Eating Awareness, Slim chance)
IAC	"Molecules in Living Systems" (Understanding the Structure of Biomolecules)

Publisher/Program	Activities/Assignments
ISIS	"Using the Skies"
HSP	11321 "Space Travel" KK308 "The Solar Merry Go Round" KK329 "A martian Test" KK330 "Martian Tales" KK331 "Four Views of Mars" KK336 "Heavenly Motion"

Publisher/Program	Activities/Assignments
SCS/13	"Using the Environment"
OBIS	"Sound Off" "Plants Around A Building" "Cool It" "Water Keepers" "Obis Oil Spill"
HAP	"Environmental Health and Safety" (Fallout)
USMES	"Manufacturing" "Nature Trails" "Growing Plants"
ISIS	"Sharing the Earth" "Things that Last" "Know the Bug" "Snakes and other Critters" "Plants Indoors"
SCINSOC	"Agriculture" "Looking to the Future" "Mineral Resources"
CREST	"30,000 BARRELS of GOO: The Disposal of Toxic Chemical Wastes"
HSP	CC344 "Rock Around" CC345 "Streaming Along" CC330 "Ice-Water-Ice" CC310 "Who Survives" CC309 "Earth Movers" CC305 "Tree Rings and Time" FF339 "How Clean is Your Air"
PLT	Supplementary Activity Guide Grades 7-12 "Environmental Awareness" "Societal Perspectives on Issues" "Life Styles"
APAP	"p(H)ossibilities" "Eternal Emissions" "The Better Buffer"
IAC	"Form and Function" (PESTICIDES. . .) "The Delicate Balance"

Publisher/Program	Activities/Assignments
SCINSOC	"Population and Health"
USMES	"Designing For Human Proportions" "Traffic Flow" "Play Area Design"
ISIS	"Packaging Passengers" "Sharing the Earth"
SC5/13	"Minibeasts"
HSP	FF344 "How long Do People Live?" FF337 "Geography of Life and Death" KK323 "The Unknown Millions" KK312 "Human Ideas About Disease" CC303 "GA and the Beanstalk" CC304 "The More the Better?" CC311 "Change and Change Again? CC318 "Me Now, Me Then, Me When" CC321 "On the Move" CC322 "Technoland" CC323 "Changing Behavior" CC324 "Community Change?" CC328 "Architectural Change" II304 "Shelter" II305 "Shoes" II303 "Food Preservation" FF332 "Pets and People"
OBIS	"Population Game"
Food. . . Your Choice (NDC)	Level 4 Social Studies (Activities 1-18)

Publisher/Program	Activities/Assignments
HSP	KK300 "Ways of Knowing" KK315 "Knowing About the Brain" KK325 "The Very Different Ones" CC306 "You, the Animal Trainer" CC329 "Changing Numbers" II313 "You and Other Great Inventors
SC5/13	"Ourselves"
ISIS	"Ways We Learn" "Birth and Growth"
SCINSOC	"Nature of Science"
USMES	"Ways to Learn/Teach"

Publisher/Program	Activities/Assignments
HSP	FF346 "Emergency Care in Your City" FF347 "Health Alert" FF348 "Where Can You Get Help?" FF350 "Health Journal" FF319 "Will your career Affect your Ear?"
HAP	"Environmental Health and Safety" (Epidemic, Fallout, Testing, Depth Perception)
ISIS	"FIRE!"
USMES	"School Rules" "Play Area Design and Use"
SCINSOC	"Industry: Organization and Obligation" (Mercury Poisoning - the Mad Hatter's legacy)

Publisher/Program	Activities/Assignments
USMES	"Bicycle Transportation" "Getting There" "Nature Trails" "Pedestrian Crossings" "Traffic Flow"
ISIS	"Packaging Passengers"
HSP	II322 "Airplanes" II321 "Space Travel" II323 "The Power of Humans, Horses, and Other Machines"
CREST	"Exhaustive Measures: Auto Emission Standards."

Publisher/Program	Activities/Assignments
CREST	"Common Heritage: The Mining of the Seabed Controversy"
ESS	Drops, Streams, Containers
SCINSOC	"Industry: Organization and Obligation" (Oil Pollution of the seas)
ISIS	"Sharing the Earth"
HSP	CC345 "Streaming Along" CC307 "Cool It"
Dairy Council	SOCIAL STUDIES BOX "Cod Fish War"

Publisher/Program	Activities/Assignments
Mt. St. Helen's Curriculum Materials Project	Total/Parts of Project
HSP	KK342 "The Storm" CC347 "Piecing it Together"

Publisher/Program	Activities/Assignments
SC5/13	"Children and Plastics" stages 1 & 2
SCINSOC	"Looking into the Future" (War in the 20th century)
ISIS	"Physics of Sport" (missile speeds, trajectories, etc.)
HSP	II308 "War Machines" FF334 "The Sirius Strain" FF335 "Trapping the Wild Microbe"
IAC	"Form and Function" (Poisons and Chemical Warfare)

Naive Conceptions of Science & Instruction

Audrey B. Champagne
University of Pittsburgh
Pittsburgh, Pennsylvania

One of the most striking recent developments in our understanding of science learning has been the discovery of the extent and persistence of the naive conceptions about the natural world that students bring with them to the classroom. It all began with the observation that, in physics and other sciences, even students who do well on textbook problems often do not apply the principles they have learned to predicting and describing actual physical events. Further investigations revealed that these students' failures were not due to an absence of theories, but rather to the persistence of naive theories that they brought with them to the science class, theories that stand in marked contrast to what students are expected to learn. Evidence is accumulating that these naive theories and the distortions they engender in students' comprehension of instruction are among the principle causes of students' failure to achieve understanding in science.

These discoveries are challenging educators and theorists to rethink the role of knowledge in learners. In most of our past thinking about the role of knowledge in learning, emphasis has been on positive transfer--that is, the facilitating effect of knowing something on learning the next concept or skill in a hierarchy. With recent research revealing the power of students' existing knowledge of science to interrere with rather than enhance learning, we are faced with a new kind of instructional problem: how to effectively confront naive conceptions so that the science knowledge represented in the instruction can be successfully learned and applied.

Characteristics of Students' Naive Conceptions

Our findings that students' conceptions of motion are both pervasive are corroborated by the research of a number of other investigators. Various

empirical studies conducted by science educators demonstrate that, for several science content areas:

1. People, young and old, have descriptive and explanatory systems for scientific phenomena that develop before they experience formal study of science.

2. These naive descriptive and explanatory systems differ in significant ways from those students are expected to learn in their study of science.

3. The naive descriptive and explanatory systems show remarkable consistency across diverse populations, irrespective of age, ability, or nationality.

4. The naive systems are remarkably resistant to change by exposure to traditional instructional methods.

Interactions Between Naive Knowledge and Instructional Events

The issue of what role the students' existing knowledge plays in their subsequent learning is of continuing concern in instructional theory and design. Traditionally, it has been assumed that the knowledge that the student already possesses will facilitate further learning. However, our work has demonstrated that students' existing knowledge can also adversely affect their ability to learn from science instruction. Our research indicates that it is not the students' lack of prior knowledge that makes learning mechanics so difficult, but rather their conflicting knowledge.

The naive theories about the motion of objects that students bring to instruction consist of well-formed notions that have been reinforced by the students' experiences. However, their notions may contradict the tenets of classical physics, and it is these notions that tend to interfere with the learning of mechanics. Often the influence of the students' conceptions is to inhibit their understanding or distort their observations and interpretations of experiments. Certain of the students' difficulties can be attributed to

the fact that many of the terms used in classical mechanics are used in everyday life--terms such as acceleration, momentum, speed, and force. The meanings of these terms as used by physicists are more precise and only partly overlap with the way in which they are used in everyday life. Thus, we observe that students misinterpret mechanics instruction because they interpret physics lectures and textbooks in the context of their everyday understanding of the terms, rather than in the way in which the teacher or text is using the terms.

Our research demonstrates specific ways in which students' conceptions influence (a) their observations of experiments and demonstrations; (b) their interpretations of their observations and (c) their comprehension and remembrance of science texts and lectures.

Ideational Confrontation

Ideational confrontation is a teaching strategy that applies the principle of verbal interaction to facilitate schema change. The strategy requires that, in preparation for instructional events (demonstration, laboratory exercise, problem solution, reading text), the physical situation which provides the instruction's context is described for the students. For example, in the case of a demonstration or lab exercise, the instructor displays the equipment and describes the procedure. In the case of a problem, the physical situation is described. In preparation for reading text, the physical exemplars used in the discussion are described.

To illustrate this preparatory phase, the motion of a balloon as the air rushes out of it is frequently used as a teaching exemplar of action and reaction (Newton's Third Law). After the physical situation is described to the class, each student engages in the analysis of the physical situation and states (aloud or written) the concepts, propositions and variables that are relevant to the situation. In the case of the balloon, they would be

asked to describe in detail the motion of the balloon as the air is released. After each student has analyzed the situation, a class discussion begins and individual students present their analyses of the situation. An individual student's analysis is elaborated and modified by other students whose analyses are essentially in agreement. Inevitably, controversies arise, usually identified because of differences in predictions about what will happen. Typically, two students with alternative perspectives begin to attempt to convince others of the validity of their ideas. As a student or group of students defends a position, the terms become better defined, and underlying assumptions and rules are stated explicitly. The net result is that each student is explicitly aware of his/her analysis of the situation of interest.

At this point, instruction in the traditional sense begins. For example, the instructor does the demonstration and presents a theoretical explanation of the results, or the instructor presents the theory (e.g., action and reaction) and explains why the example (e.g., balloon) is an instance of the rule. The students are then asked to compare the elements of their pre-instructional analysis of the situation with the one they have been taught and to identify similarities and differences. This exercise forces the students to confront inconsistencies between their pre-instructional knowledge and the content of the instruction. In the absence of such confrontation, we all too often observe students who possess logically inconsistent school-learned propositions. A favorite example that surfaced in a discussion of objects in free fall concerns two propositions about gravity. The students had learned and were quite satisfied with the proposition that objects of different mass but the same volume and shape fall at about the same rate because gravity pulls equally on all objects. This same group of students also agreed that weight is a measure of the pull of gravity on an object. We

asked these students to consider this line of reasoning: Gravity pulls equally on all objects. Weight is a measure of the pull of gravity on an object. Therefore, all objects have the same weight. When confronted with this argument, the students were flabbergasted, but more importantly they were ready to seriously reconsider the validity of the two original propositions.

Ideational confrontation is but one part of the solution to the instructional problem of schema change. Its major contribution is that it creates awareness in the student of the deficiencies of his/her current theory. However, as the following scenario illustrates -- there is still much more to be done.

One day a student who had spent approximately 10. hours convincing herself that objects of equal volume and shape but different mass fall at about the same rate went to her instructor and said: "Look, I have observed that these two balls (tennis, baseball) fall at the same rate and I believe that gravity pulls harder on the baseball - it's heavier. I just can't figure out how both of these can be true." "Well," said the instructor, "you're forgetting something important." "What's that?" asked the girl. "Inertia - do you know about inertia?" "Yes, inertia is the tendency of a body in motion to remain in motion and a body at rest to remain at rest unless acted upon by some outside force. But what does that have to do with these (the balls)?" The girl recognized the deficiency in her schema, and had the information necessary to remediate it but she was still a long way from putting it all together. While in theory it seems that it should be easy to get students to be explicit about their analysis of physical situations, in practice it is difficult. Often, for example, when students are asked what they mean by a scientific term, they can give a textbook definition but cannot explain it. It is very difficult for students to be explicit about rules they are applying.

For example, what are the rules that you use to decide the forces that are acting on an object?

It is also difficult to get the kids to talk to each other and to treat each other's theories with respect. Some kids - especially girls - find it difficult to risk an opinion. Others - especially the boys - go to great lengths to rationalize a new position. It's difficult for the teacher to get across the idea that the right answer is not important but the quality of the analysis is.

Ideational confrontation is an instructional strategy that makes naive conceptions work for the learner rather than against him. The strategy makes the learner aware of his existing theories and the need to reconcile them with the scientific concepts and propositions he is trying to learn. In this way, the possibilities for misinterpreting instructional events can be minimized. While the ideational confrontation strategy cannot guarantee that the learning of science will be much less difficult, it does help the student to understand where the difficulty lies.

NSTA's 1982 Search for Excellence

Robert E. Yager
Science Education Center, University of Iowa

The National Science Teachers Association has conducted a search for excellence in five categories for 1982. The Desired State conditions formulated by the Project Synthesis research team (see NSTA's Volume 3, What Research Says series) were used as the criteria for the search. An abbreviated listing of criteria and the five categories include:

ELEMENTARY SCIENCE

1. Focus on effective consumer behavior
2. Deal with effective personal health practices
3. Recognize people effect on environment and vice-versa; develop custodianship
4. Observe variation in interpretation of some data
5. Experience the hard work involved with resolving problems
6. Focus on great variety of "basic" sciences
7. Recognize the "people" involved with scientific pursuits

BIOLOGY

1. Use of knowledge to understand self
2. Use of knowledge to benefit quality of life and living for humans
3. Study of humans in natural and total environment
4. Focus on current issues and deal with morals, values, ethics, and aesthetics

PHYSICAL SCIENCE

1. Application of physical science ideas and information to real-world problems
2. Content displayed in context of socially relevant problems; also as science "disciplines"
3. Focus on personal needs, societal issues, careers related to physical science
4. Deal with real people in science where processes they used can be observed
5. Instruction includes real research and out-of-school experiences as well as standard laboratories

INQUIRY

1. Teachers value inquiry, encourage such as orientation and possess such personal skills
2. Classrooms use science objects and events where students focus on investigation
3. Curricula and units of instruction give attention to science processes, the nature of inquiry, and necessary attitudes and values

INQUIRY (cont'd)

4. Teachers act as role models in debating issues, admitting error, examining values, and confronting their own ignorance
5. Instruction focuses on exploration rather than "coverage"

SCIENCE/TECHNOLOGY/SOCIETY

1. Use of knowledge to improve personal life and to cope with increasingly technological world
2. Deals with technological-societal issues
3. Focus on decision-making
4. Provides accurate picture of opportunities and requirements needed for wide variety of careers

Developing Creativity as a Result of Science Instruction

John E. Penick
Science Education Center, University of Iowa

Research into creative processes and products has had only a meager effect on curriculum development in science. One possible reason that creativity has not been included directly in the science curriculum is disagreement about what creativity is, its relationship to science, and the nature of its products and processes. Although we need not assume universal meaning for the word creativity, we perhaps should study the variety of meanings which in practice are assigned to the term rather than attempt to discover some ultimate meaning. Perhaps this is what Torrance was attempting to do when he wrote that creativity is:

> ...a process of becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, disharmonies, and so on: identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them; and finally communicating the results.

The emphasis here is on direct, primary experience--experience in which individuals use their own senses to perceive reality freshly and spontaneously. In this light, creativity might be thought of as looking at one thing and seeing another. Such a definition is perhaps more applicable to the science classroom than other arenas since it rationally parallels the well agreed upon processes of science and involves observable activity on the part of the participating individual.

Creativity Helps Teachers as Well as Students

Individuals have been shown to benefit in a variety of ways from their own creativity and that of others. Studies have shown that creative people are more flexible in new surroundings, more observant, and more self-confident than less creative people. They are more adaptable and sensitive to their surroundings and to others. Creative boys demonstrate more sociability than

less creative boys. In a study which has been replicated several times, Getzels and Jackson found that creative ability can compensate for lower IQ.

Creativity is, in some respects, a great equalizer--a particularly attractive quality in a democracy. Creativity helps to fuse what are traditionally considered feminine and masculine traits. Sensitivity, usually considered a feminine trait, and creativity go hand in hand. Less creative women are more submissive and hesitant while more creative women exhibit more initiative. In fact, creative women are seen to demonstrate more than average aggression and dominance, traditional masculine traits. Creative women are also less passive, less restricted by society's expectations, and better able to explore a variety of alternative behaviors.

Highly creative children, when compared to less creative children, have a greater level of self-sufficiency, feel more secure, are more flexible and dependable, and exhibit a healthier participation in group activities. Highly creative boys, especially, exhibit a higher level of maturity and social skill, and feel that discipline is more fair. In addition, these more creative boys exercise better overall social judgment than their less creative peers.

Creative people have a well-developed ability to sense problems. They possess originality and flexibility which is spontaneous and adaptive. Their fluency of associations, expressions, and ideas allows them to relate and perceive ideas in unusual ways. This leads to a redefining and juggling of ideas, further visualizing, and still more elaborating. The tendency to think at right angles to the mainstream and to develop an ability to focus attention in many ways while working and thinking on problems is very common. Creative people also show an ability to evaluate their own creativity, an ability perhaps related to their generally strong drive, inner-directedness, self-confidence, intellectual thoroughness, and aspiration to making theoretical

and original contributions. A high degree of self-sufficiency, openness to the irrational, intuitiveness, awareness of their own impulses, and resourcefulness often lead to the creative acts, products, or ideas which characterize creative individuals. Being adventurous, personally complex, unconventionally employed, dedicated to and involved in their work, and liking to think and to toy with ideas may all promote the stamina and endurance which creative people are seen as having. A need for variety and autonomy, a preference for complexity and challenge, a striving for better and more comprehensive answers, a need to improve on currently accepted systems, a need to adjust the environment (rather than adjust to it), and a tolerance of ambiguity may all contribute to the creative individual's tendency to stand out from the usual, the accepted, and the conservative trends of peers.

Using the Classroom to Promote Creativity

The ability to do creative work and creative thinking has been shown to be largely dependent on a pupil's opportunities for creative work. The weight of present evidence indicates that people fundamentally prefer to learn in creative ways by exploring, manipulating, questioning, experimenting, risking, testing and modifying ideas, and otherwise inquiring into their environment.

Several educators have suggested ways in which we might help students develop creativity. If the curriculum were arranged to encourage students to engage in as many kinds of thinking as consistently as possible, we would in all probability: (a) provide them with bases upon which to recognize opportunities to transfer learning; (b) expand their capacities to respond in several ways to a single phenomenon; (c) improve their abilities to select an effective way of thinking about a task; and (d) provide them with cognitive alternatives they might otherwise have ignored.

People tend to learn and develop along whatever lines they find rewarding. To promote creativity, science educators might structure the curriculum

so that creativity is valued and encouraged. With this in mind, we can reward creative behavior by treating unusual ideas and questions with respect while showing students that their ideas have value; providing opportunities and credit for self-initiated learning; and making evaluation contingent on causes and consequences.

Many psychologists and businessmen have used brainstorming techniques to develop a flow of ideas from individuals. These techniques include deferring judgment and making conscious efforts to adapt, magnify, minify, substitute, rearrange, or combine ideas. Other methods that have been successfully used to develop creative potential include sociodrama and synectics.

Many ideas could be developed into specific creativity-stimulating classroom activities. For example, pretending, where students examine their environment by role playing objects or people in their environment. In body-twisting, students cast themselves into unusual physical positions in order to view the environment from different vantage points. In other activities students brainstorm to see how different characteristics of an object might be related to its function. Students may also try to change the object to better serve a given function and then compare the new object with other objects. Along with this, they may develop as many ways as possible to use the new object and then write a story using it.

An environment which enhances creativity will be promoted by teachers who exhibit creative behavior themselves and who eliminate as many cultural and emotional blocks as possible. Many of these blocks involve the effects of conformity, excessive faith in logic, fear of mistakes or failure, self-satisfaction, perfectionism, negativism, and a lack of independence combined with a reliance on authority. As in the brainstorming process, teachers can help students to defer evaluation and judgment and to concentrate on producing

ideas before becoming critical. While this may be viewed as rather permissive, openness and self-directiveness have been shown to characterize environments which facilitate goals associated with creativity. Additionally, it has been shown that evaluation inhibits curiosity, stifles inquiry, and encourages undue dependency. To encourage self-directed learning, we must refrain from arbitrary evaluation and help children learn how to determine and apply specific criteria when evaluation is finally appropriate.

The Creative Future

Although we have been riding the crest of an information explosion, we may not have been increasing our creative potential at the same rate. Increasing the number of creative citizen-workers can serve to enhance the future for all, and schools and influential teachers can play an important part in the process of developing creativity. Schools are likely places for these opportunities to unfold, but they won't unfold by themselves; an environment with subject matter and intellectual freedom to facilitate creative development is necessary and can be promoted by teachers.

Creativity can be fostered in most children and many will experience significantly enhanced creativity as a result of teaching techniques emerging from research on the development of creative potential. The following list might be thought of as a research-based prescription for a future in which education is a generative pleasure and continuing education, an ecstasy of creativity.

Teachers Should Encourage Creativity in Students By:

1. Accepting unusual ideas, questions, or products.
2. Providing opportunities, including materials, for creative work.
3. Showing students that we feel their ideas have value.
4. Asking students to examine causes and consequences in order to make personal evaluations.

5. Providing an environment in which it is safe for students to risk, question, experiment, and test.

6. Allowing students to make decisions and choices.

7. Reducing student anxiety.

8. Allowing students to decide on closure of an idea, experiment, or train of thought.

9. Allowing students opportunities to take leadership responsibility.

Teachers Should Not:

1. Evaluate arbitrarily or permaturely the product or the process.

2. Restrict access to ideas or materials.

3. Emphasize norms or generalities.

4. Constrain student freedom unduly through the use of directions or praise.

5. Hasten or enforce closure.

Students Should be Encouraged to:

1. Evaluate themselves.

2. Interact with objects, materials, and ideas in an atmosphere of intellectual freedom.

3. Make decisions about their learning.

The Crisis in the Science Classroom

Robert B. Sigda
Memorial Junior High School
South Huntington, New York

Like my fellow science teachers, I am concerned with the future of public education in this country. I am proud to call myself a science teacher, but the constant attacks are tiring. For far too long, science education has been the target of criticism and attack.

Newspapers have carried an endless number of headlines warning the public about the "crisis" and "decline" of science education in our nation's schools. We have recently entered a complex technological age when students are in need of a good science program to take their place in this modern society.

The history of science education reveals a continuous cycle of ups and downs. The most recent "up" period followed the lift-off of Sputnik I. Science reigned supreme--the answer to the nation's problems. The National Science Foundation promoted science and science education. Funding became available and new materials and programs were developed. But as one would expect this euphoria ended in the 1970's. Once again, however, the tide appears to be turning in favor of science education--but it won't change by itself.

Successful science teaching today is a complex interaction of student and teacher involvements with the program, classroom, home, and the local and national community. Successful learning at all levels ultimately depends on the classroom teacher.

Teachers, especially science teachers are facing a daily "identity crisis". They need a tremendous revitalization of spirit. The constant attacks are befuddling and demoralizing to science teachers because, for

the most part, they are trying to do a good job. In this period when science teachers should be filled with enthusiasm, they are frustrated.

Much of the problem is the lack of funding. The recent suggestions by some that all funding for science education must come from the local level is totally unrealistic to science teachers, who, for many years, have been trying to obtain money from these sources. Anyone familiar with the problems and pressures on local school boards knows that little, if any, funding is available from this source. Further, there has been a fiction that massive federal support for pre-college science education has been present over the years. The fact is federal support for pre-college science education has declined steadily and drastically for the past 22 years, until today, it is essentially zero.

The Identity Crisis is compounded when President Reagan appointed a National Commission to study the problems in science education, he didn't appoint any science educators to the Commission.

A major problem of the Identity Crisis is teacher recognition. Like all people teachers like to be told when they are doing a good job. Unfortunately, most teachers' recognition is negative. It's the call to the Principal's office where everyone wonders what it is you have done wrong. It's the lack of support for homework and discipline.

The worst kind of negative recognition occurs when teachers meet "friends" and a discussion about education ensues. When teachers are criticized, these "friends" are sure to say that it doesn't apply to you, however. In this manner, they actually bring you into the discussion on their side. You should not put up with this. There are far too many good teachers, to allow our "friends" to get away with this.

We are all familiar with the overworked and underpaid remarks. Peer

jealousies and the lack of recognition by the administrators and the school board is negative reinforcement. Many of you have probably also heard of the convention vacation.

What teachers need is more positive reinforcement, more positive strokes, if the science teacher is to achieve a better self image. More awards, both locally and nationally are needed. Further, recognition at the local level, by students, peers, parents, administrators and the school board is needed.

In the area of curriculum, the most demoralizing reality is the constant comparison made between the United States and other countries. It is the science teacher who is criticized because more students in other countries take science than do in the United States. The fact is that, in the United States, students elect science courses, while in other countries, science is required.

We seem to be in a time when students want easier courses that offer more fun. But, can we really afford to make our courses easier or more fun? In fact, with science and technology advancing at such a rapid rate, the opposite is probably true. The easiest way to resolve all these problems would be to require states, without requirements, to make science education mandatory for every student K through 12.

Another important curriculum concern is the debate between process which stresses analytical thinking and content which stresses facts. Well, neither students nor adults like to spend all their time thinking. But, neither do thy like to spend all their time memorizing. Both types of courses have been tried, and neither extreme could be called a success. The time has come to take the best of both and develop a balanced program--on offering both process and substance.

The "add-on" curriculum is another cause of concern to science teachers. These are units designed to solve many of the nations problems. You've all taught them at one time or another. Who can ever forget Earth Day, or Solar Day and all the other units in sex education, drug and alcohol education, and, now, computer education for which we had to design special programs. The problem, of course, is that while all this other material was being added, the regular curriculum was expected to be maintained.

Add to this, the implications of the recent findings in brain study and the way learning takes place. These findings may require that entire programs of instruction be drastically altered, and that can be frightening to science teachers. Not because teachers fear change itself. They welcome any change that improves their classroom situation. But the fear arises from not knowing how to incorporate all this new information into their program.

The final point I would like to mention here relates to the qualifications and re-education of teachers. First, surveys taken by the National Science Teachers Association show that over 50% of new science teachers employed in 1980 and 81 were "unqualified" and employed on an "emergency basis". Further, many studying to become science teachers do not enter the field. Over 79% of those teaching have not completed 10 credit hours of science in over 10 years. In addition, 69% had never taken a course or workshop in computers. About 40% have not attended a course or workshop since they began teaching--an average period of 16 years.

At the elementary level, 51% of elementary school teachers reports that their undergraduate training did not prepare them to teach science. Further, 71% of these districts had no science inservice training, and 64% no longer had science consultants.

More teachers are leaving the profession today for employment in non-teaching jobs than are leaving due to retirement. Can the country afford this brain drain in science? I think not!

It is obvious that the re-education of teachers deserves a high priority. A number of programs could provide this service. The most appropriate would be of the type used by NSF in the past--where support for tuition, housing, and travel was provided. However, the goals this time would have to be different from the goals of previous institutes. Other forms of re-education would include inservice training, on job workshops, conventions, and conferences. No matter what the approach however, these programs all require time and/or outside funding.

There are no panaceas, no quick fixes to the problems of science education. Science teachers, science educators, scientists, industry, the local and state and federal government--all of us--must unify our efforts, and work together to solve this major problem in our country.

LINKING TEACHING BEHAVIORS TO STUDENT OUTCOMES

David P. Butts
Department of Science Education
University of Georgia
Athens, Georgia 30602

The problem seems straightforward. If we know what teaching behaviors are associated with high student achievement in science then teachers can use those behaviors and students will learn. Look who will be happy: parents, taxpayers, supervisors, school boards, and maybe even the Department of Justice.

But if we do find an answer to this question will the answer do any good? One aspect of this question is how to search for the answer. There are at least four contrasting strategies.

Strategy 1 is to find out who are successful teachers. Thus, one teacher characteristic of the strategy implies that if we study these teachers, master their model, we will be successful. The results of this strategy indicates that success is related to teacher sincerity, empathy, friendliness, and warmth. But we are aware of many teachers who have these characteristics but who have wide variations in student achievement.

Strategy 2 focuses on teaching behaviors rather than teacher characteristics. In this strategy, if we find out what successful teachers do we can write modules to help other teachers learn these behaviors and they will be successful. Following this strategy we have been able to help teachers learn questioning strategies, clarity of explanations, and task orientation. But many teachers who have acquired these teaching behaviors still have wide variations in their student achievement.

Strategy 3 focuses on student characteristics; that is, find out more about who is being taught. Listing their characteristics we then can know

who will likely be successful in science. Correlations between achievement and such student characteristics as gender, aptitude, TV viewing, then will help in understanding why some students are not expected to learn. But some students do learn in spite of the prediction of the characteristic.

Strategy 4 focuses on what students are doing. In this respect the most exciting findings suggest that the more time students practice the better they perform. This seems to be true in performance on piano, the cello, chemistry, or microbiology. The on-task time of the majority of the students is a key factor in understanding the variance in achievement.

It is true that a teacher usually has little direct influence on what has happened to the student prior to their class. What happens to the student outside the school and on the textbook would be useful in the school. But teachers do control the interaction between themselves, their students, and the curriculum. How much time in school is not controlled by the teacher. How much of the classroom period the teacher teaches is controlled by the teacher. This linkage between what students do and what teachers do is embedded in the three main tasks that teachers have.

A. Being the Supply Sergeant or classroom management.

B. Being the Intelligence Officer or instructional planning.

C. Being the Chaplain or classroom interaction.

My study leads me to extend this to say that in these three tasks there are six target areas of teaching behavior. These targets also include:

1. Subject matter competence
2. Structure
3. Physical organization
4. Motivation
5. Rapport
6. Response opportunity

Thus there are eighteen ways I as a teacher can link my behaviors to enhance student behaviors that will help them to be on-task and stay on-task.

Can you teach equally well with and without students performing? If as teachers, we are clear, business-like, task oriented, and if the teacher is real, the students will be on-task and will have higher learning achievement.

Target	Supply Sergeant or Classroom Management	Intelligence Officer or Instructional Planning	Chaplain or Classroom Interaction
SUBJECT MATTER COMPETENCE (Tough to come back from where you haven't been.)	Do it yourself first.	Plan variety of examples--one will not win the concept.	Fit explanations to student level of understanding.
STRUCTURE (To what extent do you--and your students know the name of the game?)	Minimum time dissruptions--transition between activities.	Teacher directions --established routines.	Increase on-task by being on-task yourself. (Business-like--structured.)
PHYSICAL ORGANIZATION (Stuff, time, space.)	Wipe out non-productive confusion.	Cut non-curriculum activities (silent role call--sign in sheet--seating chart).	Think ahead--where are your students. Spending time waiting--for stuff or you?
MOTIVATION (To what extent is this experience matched to the students interest?)	What's in it for him to fit your rules?	Know your students' variety of interests--be contemporary with 1982 (not 1962).	Be enthusiastic/ interested. They will be no more interested than you are.
RAPPORT (How well do you like your students--and how well do they like you?	Be available--as one who will listen even when providing feedback as to unacceptable behavior.	Provide for time to express opinions and feelings--within preset boundaries.	Maintain two-way communications and encourage reinforcement from others--be an example.

Target	Supply Sergeant or Classroom Management	Intelligence Officer or Instructional Planning	Chaplain or Classroom Interaction
RESPONSE OPPORTUNITY (To what extent do you allow students to contribute and do you use it if they do?)	Student input to classroom routine. (Tell me how we could improve this lab?)	Reflect on your questions/How to get them to do the asking.	Increase your wait time. "I believe what you have to say is so important, that I am waiting to hear you." Active Listening versus waiting for you to finish so I can say what I've decided I am going to say before you interrupted me.

SCIENCE EDUCATORS AND POLICY-MAKERS

Audrey Champagne
University of Pittsburgh
Pittsburgh, Pennsylvania

This paper addresses three points: (1) the appropriateness of political activities on the part of educators; (2) the political responsibilities of educators; and (3) how educators can use political activism to achieve political goals.

Political activity on the part of educators is appropriate, necessary and reasonable. It is appropriate because active participation by all citizens is a basic premise of our form of government. The political system is adapted for participation by all citizens. Why then don't educators participate in government? It seems that there is a perception on the part of educators that professionals should not become involved with politics because politics is tawdry. Educators seem to believe that politicians are self-serving, that they are in politics for personal glory and financial gratification. An alternative perspective is that politicians want to serve the public good. To achieve this goal the politician must remain in office. Another reason for non-participation by professionals in politics is the belief that compromise and politics go hand in hand. This is a true statement, however it is possible to participate in politics without being compromised. The demands that the politician makes of the public are reasonable and appropriate. They want your support: votes, campaign support-services or money; and your ideas and expertise. A third reason educators don't participate is because they don't have time. This is a dangerious position to take. You must take the time - it is in your personal and professional interest to take the time. The well-being of our profession and those we serve is placed at risk if we allow important decisions to be made without being heard. Participation is also important because it helps

us to dissipate feelings of powerlessness.

The survival of our profession necessitates our active participation in the political process. The consequences of our lack of political initiative is potentially disastrous. The responsibility for the content and delivery of science instruction may well be taken over by the military and the private sector with the advice and consent of the scientific community and the social scientists unless science educators make themselves heard. We must seize the opportunity that the current national concern for scientific and technological literacy affords us.

The educator has two political responsibilities: one is to be informed about the issues and the political process and the other is to be heard. An issue of current importance is growing national concern that the current level of scientific and technological literacy threatens the nation's economic well-being, military strength, and citizen's ability to participate intelligently in the democratic process. There is agreement about the magnitude and importance of the problem. However, its causes and possible solutions are matters engendering considerable debate. One thing is clear: the Reagan administration's policy is to get the federal government out of education. The reduction of $787 million dollars in aid to education and the demise of NSF's Science Education Directorate demonstrate the administration's success in implementing the policy. There is evidence that the administration is not about to modify its policy.

Recently (12-13 May) the National Academy of Science convened educators, scientists and government officials to consider the national crisis in scientific and technological literacy. The meeting gave administration officials the opportunity to learn more about the problem. Evidence was presented to show that:

(1) enrollments in pre-college science courses are low;

(2) science and mathematics achievement is poor; and

(3) other nations are doing a better job of teaching science.

The response from the administration was provided by Terrel Bell, Secretary of Education, and Edwin Harper, presidential assistant for policy development. Bell urged that the problem be solved by emphasizing educational excellence, and both men made it clear that the administration has no intention of "throwing money at the problem." The administration will, however, seek the participation of the private sector to meet the crisis. This has serious implications for science education. For example, industry has the mechanisms in place in Washington to influence Congress - in a word, to lobby; science educators must also be prepared to influence Congress. If we don't we may all give up all control over the conduct of our profession.

The characterization of the current crisis in science education by the scientific associations also necessitates political activity on our part. For example an article in Chemical and Engineering News (24 May) (the weekly newsmagazine of the American Chemical Society) attributes scientific illiteracy to the failure of public education. The consequences of our not taking the responsibility of helping associations such as the ACS to reformulate the cause for the crisis in a more positive manner are potentially disastrous. We must help the professional scientists understand that our task as educators is becoming more difficult. We are being asked to educate students of lower ability to levels of competence traditionally required only of the most able in a social milieu where science, academic pursuits and hard work are undervalued. We must educate others to recognize that education is as intellectually demanding a discipline as physics and that we are developing more effective means of teaching science. The times demand that science educators take their political responsibility to

be informed and to be heard.

As individuals and as an association we must be informed both about the issues and the political process. We must be prepared to get our message to all levels of government, to other professional associations, to the public and to industry.

Active participation in politics requires that you be informed. How well-informed are you about the issues and the political process?

The questions that follow will test your knowledge of the current federal scene on science education and the political process.

PIQ Test

1. What has each of these men said or done recently that has important implications for science education?

   Harrison Schmidt

   John Glen

   Don Fuqua

2. What are three national associations that share NSTA's interest in science education?

   How does each characterize the current crisis?

3. What are the names of your representatives in Congress?

   Senators -

   Representatives -

4. For each person named in question three, list that person's committee assignments.
5. Name the congressional committees that control the budget process.
6. Name the congressional committees that are important to science education.
7. What is a dear colleague letter?

The answers to these questions provide important information for

informed participation in the political process. The answers to most of them (exception is 2) can be obtained by calling the local office of your representative to Congress.

Finally, how can educators use political activism to achieve political goals? We must work to change our image, develop a statement of our professional goals and make a plan for achieving them. We must identify external support that is needed to achieve the goals. As we seek external support, we must present a united front - we must keep squabbles and debates inside the profession. We must be practical, have the facts, communicate clearly, use concise but comprehensible language and be prepared to compromise.

REFERENCES

Halpern, S. A guide for the powerless and those who don't know their own power. The Institute for Educational Leadership: 1001 Connecticut Avenue, NW, Washington, D.C., 20036, 1981.

Heylin, M. High school science problems gain spotlight. Chemical and Engineering News, 24 May 1982, 39-41.

TEACHING CITIZENS ABOUT SCIENCE AND TECHNOLOGY

Rodger W. Bybee
Education Department
Carleton College
Northfield, Minnesota

Bibliography and Resources

Barbour, I.G. 1980. Technology, environment, and human values. New York: Praeger Publishers.

Science and social science concepts are integrated and balanced in discussions of different environmental issues. The place of human values, attitudes, and ethics in present problems is very strong. Different arguments (pro and con) pertaining to technological and environmental issues are reviewed. The author then evaluates issues in light of conflicting ethical positions and suggests new policy directions. Recommended for all teachers, but especially for science teachers wishing to understand the social science side of human ecological problems.

Darnell, R.M. 1973. Ecology and man. Dubuque, Iowa: Wm. C. Brown Company Publishers.

The first half of this book is an introduction to the science of ecology. Chapters include: ecology and the individual environment, population, community, and ecosystem. The second half applies ecological concepts to human problems. Chapters include: people, environment pollution, the preservation of nature, and tomorrow. Strong in scientific content. The author does not achieve an equal balance for the human aspects of ecological problems. Recommended for science and social science teachers not trained in the biological sciences.

Hinckley, A.M. 1976. Applied ecology: A non-technical approach. New York: Macmillan Publishing Co.

A versatile book. After an introduction to the history, scope, basic principles of ecology, and problems of humans interacting with the environment, the author discusses a wide range of topics within the categories of land, water, cities, and alternatives. Each chapter has key concepts listed at the beginning, and a summary, discussion questions, suggested projects, and an annotated bibliography at the end. The book is well designed, has a glossary, and is easy to read. Ecological principles and social problems are well integrated. The role of the social sciences in resolving problems is weak. Still, this book is highly recommended for science and social science teachers.

McHale, J. 1970. The ecological context. New York: George Braziller, Inc.

Issues such as population, food, energy, and materials are described in the context of ecology. A good general overview of the problems. A balance of science and social science. Numerous charts, tables, and diagrams with valuable information make this a good resource for teachers.

Miller, G.T. 1972. Replenish the Earth: A primer in human ecology. Belmont, Calif.: Wadsworth Publishing Co.

The subtitle of this book is "a primer in human ecology" and it is just that. The chapters provide an excellent introduction to human ecology as a way of understanding and resolving population, hunger, pollution, and other problems. The last chapters give concrete direction: "a case for hope" and "what we must do." Recommended for all science and social science teachers.

Miller, G.T. 1979. Living in the environment. 2nd ed. Belmont, Calif.: Wadsworth Publishing Co.

Humans and nature: an overview, and an introduction to some ecological concepts are the first two sections of the book. Part 2 is on population, resources, and pollution (with several chapters on each). The last section is on earthmanship: environment and society. The best all-around text available, basic science and social science concepts are presented, all the issues are outlined, and excellent use is made of diagrams and charts. Excellent bibliography, glossary, appendix, and a useful set of enrichment studies on topics such as world climates, ecology and the poor, food additives, land use, noise pollution, and the limits to growth debate. An excellent basic resource for all teachers. If you are only going to buy one book, it should be this one.

Richardson, W.N. and Stubbs, T.H. 1976. Evolution, human ecology and society. New York: Macmillan Publishing Co.

Evolution, both biological and cultural, is the dominant theme of this work. This is the context of discussions of the human past and future. Clearly written and well documented. The anthropological receives greater attention than social, e.g., ethics, economics, politics, in presentations of a broad perspective of environmental degradation and its effect on human evolution. Specifics of present social problems (pollution, population, energy) are dealt with in the context of the evolutionary process. The book is recommended for all teachers, and it certainly delivers on expectations derived from the title.

Southwick, C.H. 1976 Ecology and the quality of our environment. New York: D. Van Nostrand Co.

The strength of this book is organization. The first part shows the relevance of ecology to human affairs--pollution, land use, population, energy, and economics. Then, in parts 2, 3, 4, and 5, an understanding of ecological concepts is developed in the context of the first section. Finally, in the last part the author returns to the problems and examines the prospects for the future. The science content is excellent, social science content is good, but it is not emphasized as much as science. Recommended for science and especially for social science teachers wishing to strengthen their background in the scientific aspects of social problems.

Scientific American. (ed.) 1970 "The biosphere." San Fransicso: W. H. Freeman.

This book is a collection of articles from Scientific American. Some articles are slightly technical, but they are well written and illustrated. Emphasis is on energy and various cycles (water, carbon, oxygen, nitrogen) in the biosphere. The last chapters are on human food, energy, and materials production. All articles are written by experts in their field. A good basic resource for all teachers. Like most compilations, it suffers from the lack of a strong continuous theme.

Science-Related Social Issues: Instructional Materials

Textbooks

Engineering Concepts Curriculum Project. The Man Made World, New York: McGraw Hill, 1971.

Greisel, Jensch. Investigating our Ecosystem, Boston: Houghton Mifflin, 1976. (Grades 10-12)

Rasmussen, F. et al. You and the Environment, Boston: Houghton Mifflin, 1976. (Grades 7-9)

Smallwood, William. General Science, New York: McGraw Hill, 1980.

Stone, A. H. and Sherman, L. R. Spaceship Earth: Life Sciencing, Boston: Houghton Mifflin, 1978. (Grades 7-8)

Curriculum Programs

THE CONSERVATION LEARNING ACTIVITIES FOR SCIENCE AND SOCIAL STUDIES PROJECT (THE CLASS PROJECT). Washington, D. C.: National Wildlife Federation (available 1981).

CREATION: A National Diffusion Network Project. LaSalle-Peru Township High School, LaSalle, Illinois 61303.

CREATIVE ROLE-PLAYING EXPERIENCES IN SCIENCE AND TECHNOLOGY (CREST). Social Sciences Education Consortium, Boulder, Colorado 80302.

ENVIRONMENTAL STUDIES. Menlo Park, California: Addison Wesley Publishing Co.

GLOBAL DEVELOPMENT STUDIES - A MODEL CURRICULUM. New York: Management Institute for National Development.

HUMAN SCIENCE PROGRAM (BSCS). Batavia, Illinois: C & F Associates, Inc., Distributor.

INNOVATIONS: THE SOCIAL CONSEQUENCES OF SCIENCE AND TECHNOLOGY. Biological Sciences Curriculum Study, Boulder, Colorado 80306.

SCIENCE AND SOCIETY AS AN ALTERNATIVE FOCUS FOR SCIENCE CURRICULUM. Ontario Institute for Studies in Education, Toronto, Ontario, Canada.

SCIENCE IN SOCIETY PROJECT. Malvern College, Malvern, Worcestershire, United Kingdom. John Lewis, Director. Also available from: Heineman Education Books, Exeter, New Hampshire 03833.

MODULES/UNITS

Acid Precipitation Awareness, Harriet Stubbs Johnson, Director, Independent School District #197, West Saint Paul, Minnesota 55118.

Benchley, D. and Towler, J. The Environment: Activities and Explorations, Boston: Houghton Mifflin, 1975.

Biological Sciences Curriculum Study. Investigating Your Environment, Menlo Park, California: Addison Wesley Publishing, 1975.

Biological Sciences Curriculum Study. Energy and Society, Investigations in Decision Making, Northbrook, Illinois: Hubbard, 1977.

Biological Sciences Curriculum Study. Investigations in the Human Environment: Land Use, Boulder, Colorado: BSCS, 1979.

MODULES/UNITS (cont'd)

Biological Sciences Curriculum . ..y. Investigations in Life Science: Man in Nature (35 mm Slide Programs), Aspen, Colorado: Crystal Productions, 81611.

Biological Sciences Curriculum Study. Quality of Life in the Future, Boulder, Colorado: BSCS, 1980.

Ecology, Toronto, Canada: The Ontario Institute for Studies in Education, 1980.

Focus on Science Module. Ecology and Human Influence, Columbus, Ohio: Charles E. Merrill, 1980.

Focus on Science Module. The Environment, Columbus, Ohio: Charles E. Merrill, 1980.

Institute for Science, Technology and Social Science Education. Ten modules for senior high school and seven for the junior high school, Rutgers - The State University of New Jersey, New Brunswick, New Jersey 08903.

Population. Toronto, Canada: The Ontario Institute for Studies in Education, 1980. (Secondary)

Resources and Activities

Allman, S. A., Kopp, O. W., Zufelt, D. Environmental Education: Guidelines for Activities for Teachers, Columbus, Ohio, 1976.

Amidei, Rosemary (Editor). Environment: The Human Impact, Washington, D. C.: National Science Teachers Association, 1973.

Barman, C., Rusch, J., Cooney, T. Science and Societal Issues, Ames, Iowa: Iowa State University Press, 1981. (Secondary level)

Charles, Cheryl (Director). Project Learning Tree, Washington, D. C.: The American Forest Institute, 1975. (Activities K-12)

Fowler, Kathryn M. Hunger: The World Food Crisis, An NSTA Environmental Materials Guide, Washington, D. C.: National Science Teachers Association, 1977.

Fowler, Kathryn M. Population Growth: The Human Dilemma, An NSTA Environmental Materials Guide, Washington, D. C.: National Science Teachers Association, 1977.

Garigliano, Leonard J. and Knope, Beth Jo. Environmental Education in the Elementary School, Washington, D. C.: National Science Teachers Association, 1977.

Scherer, Donald. Personal Values and Environmental Issues, New York: Hart Publishing Company, 1978.

Simulation Games

CONTAINMENT. Burlington, North Carolina, Carolina Biological Supply Company.

EXTINCTION: THE GAME OF ECOLOGY. Burlington, North Carolina, Carolina Biological Supply Company.

THE PLANET MANAGEMENT GAME. Boston, Houghton Mifflin Comapny.

THE POLLUTION GAME. Burlington, North Carolina, Carolina Biological Supply Company.

THE REDWOOD CONTROVERSY. Boston, Houghton Mifflin Company.

Toward Relevance in Science Education: Bases for Applications in the Curriculum

Vincent N. Lunetta
Science Education Center
University of Iowa

Erv Podulka
Science Education Center
University of Iowa

Emphasis on applications in the introductory science curriculum has waxed and waned over the years. In the early 1900's, Dewey's philosophy was translated into curricula emphasizing applications. The emphasis on applications and technology grew to such an extent that in the mid 1950's, other science curricula were criticized for including a proliferation of technology. The Physical Science Study Committee, the Biological Science Study Committee and Harvard Project Physics curricula were bold departures from the emphasis on technology. These curriculum projects of the 1960's emphasized "pure" science rather than applications. Today there is renewed support for an emphasis on relevance and applications in the science curriculum.

There are a number of important differences and similarities between pure and applied science as shown in Figure 1. For example, physics involves both pure and applied activity, and the physics curriculum should reflect this reality. An introductory science course emphasizing applications can help students understand the differences, similarities and interrelationships between pure and applied science. Applications should be included in the curriculum in the fullest sense of the term: applications to explain or interpret natural phenomena or the operation of man-made devices, applications to solve problems, and applications to societal issues.

A science course emphasizing applications is appropriate from the perspective of learning theory and student motivation. Topics in that course will be selected, in part, using student interest and societal relevance as criteria. Emphasis on applications does not necessarily mean however, that

more meaningful context and understanding of principles and concepts can be enhanced. Concepts linked to topics of interest are more likely to be remembered than a series of concepts that are perceived as sterile and unrelated. Science curricula build on the best curricula of decades past with an emphasis on applications. Applications in the fullest sense of the term can provide a rich organizational resource for introductory science courses today.

	PURE SCIENCE	APPLIED SCIENCE
GOALS	Produce knowledge Develop theories to explain phenomena	Produce devices or processes to help people
DRIVING FORCE	Curiosity about natural world	Social utility Desire to help humankind
LOGIC	Both inductive and deductive, but examples lead to generalizations	Both inductive and deductive, but general principles are applied to unique problems
CONTENT	Common body of laws and principles	
METHODS	Shared mathematical techniques Shared and mutually dependent research procedures Shared and mutually dependent instrumentation	

SIMILARITIES AND DIFFERENCES BETWEEN PURE AND APPLIED SCIENCE

Figure 1

NEEDED: SOLUTIONS FOR LINGERING PROBLEMS

Robert E. Yager
Science Education Center
The University of Iowa

A dozen or more problems continue to perplex us as we attempt to resolve the current crisis and characterize a new science for schools--a new science which provides a better preparation for students who need to prepare for life in another century. An elaboration of these problems is provided--in simple terms and with obvious correctives in mind.

First of all is the supremacy of the textbook. The recent NSF status studies reveal that ninety percent of all science teachers use a textbook ninety per cent of the time. The textbook seems to determine content, mode of instruction, evaluation and what students learn. The major curriculum decision that teachers make is choice of the textbook. Once it is determined, teachers complain about it while considering all content in the book chosen -- usually in the same order and with the instructional aids provided and/or suggested.

Another lingering problem is the implicit goal which arises above all others that the major "justification" for school science is the preparation it provides for the next academic level. Teachers frequently justify their courses, the content covered, and instructional strategies because "it is expected by teachers at the next level." Surely this is worst when secondary school teachers "expect" certain coverage. The evidence suggests that the teacher at the next level rarely expects anything and regardless of what is done at earlier levels, finds fault or ignores the experience of the students.

A third problem is one where the goals of science instruction are limited to certain knowledges and certain processes. Such a two-dimensional view is limiting and inaccurate. Like most complex enterprises of the

human being, science is multidimensional. Some of these dimensions are far more appropriate for many learners than the process and content dimensions. Some have argued that several other dimensions are far more important for achieving general scientific literacy than are process and content; some suggest that process and content are least important of all. Surely an argument about the relative importance of process and content is simplistic and an error.

Another major limitation for moving science teaching in new directions is our failure to consider science curriculum broadly and precisely. Brandwein suggests that we have never considered a theory of curriculum and that we have never had a science curriculum as such. We have been content to compartmentalize science as scientists do and to argue the "best" order of presentation of the various disciplines.

A related problem is our failure to define science content in any way other than through a discipline orientation. Most discussions of science teaching quickly reduce to a consideration of relative emphasis and sequencing of given science topics -- always those traditionally packaged in various discipline-bound courses. This simplistic view of science explains our failure with curriculum; it also explains our inability to consider other dimensions of science.

Another major problem has been our inability to move beyond the lecture as a form of instruction. Student recitation following a lecture or a reading assignment indicates another problem. This emphasis is upon presenting material (content) for student mastery. The recitation becomes a form of motivation for students who want to succeed.

Another problem exists with the so-called laboratories which characterize school science. Some studies have revealed that most science courses do not include a single experiment where students can define a problem, propose procedures, collect and interpret results; some insist that students rarely

engage themselves in activities when the answer is now known by the textbook authors, the teacher, or other students. Many activities in science classrooms are merely exercises in following directions and verification of information given by the text or the teacher.

School science is on the list of important priorities for schools as viewed by the public in a recent Gallup poll. However, science appeared next to the bottom of the list of priorities; eighteen other curriculum areas and school functions were viewed as more important. Reading was at the top of the list; the public places reading as the highest priority for the school. However, second to reading is the development of reasoning, i.e., critical thinking, logical thought, and similar terms. It is alarming to realize that the public does not associate logical thinking with science. And, it is disappointing to find that science teachers do not recognize the importance of logical thinking to science.

Another problem that remains is the "belief" of students that their study of science will be useful. Students enrolled in science are satisfied customers. They like the textbook, teacher lectures, the definitions, and the rest. In fact, the longer they stay in school and the more science they complete, the greater is their "belief" in the ultimate value of their studies. For the few winners who proceed through the system through graduate education, this may be appropriate. However, for most the disillusionment with the value of school science arises when they are adults and actively at work on a variety of careers.

Evaluation of success in school science is a problem, mainly because it mirrors the emphasis upon content for its own sake, teacher lectures, and textbook presentations. Basically students are expected to replicate what is given to them to study and to do. Emphasis upon definitions and the knowledge dimension tends to close science, to make puppets out of students,

to reduce science teaching to a concern for definitions, vocabulary, laws, etc.

It has become common to omit the human being in science courses. This occurred when all applications were removed and when the emphasis was placed upon "pure" science. All "sensitive" areas were removed or at least de-emphasized. There has been no evidence upon conflict and/or the persons actively engaged in scientific pursuits today. There has been an attempt to remove science from the society of which it has always been a part.

A final "lingering problem" is our use of a science classroom and laboratory as an exclusive setting for where science is done. We have attempted to package courses, laboratory activities in a way that they neatly fit into class periods, the school day, and the school year. We have not been quick to use the vast resources that the personal experiences of every student might bring to class. We have failed to realize that the world itself is the real laboratory for science studies. Some now feel that most of what a student knows, feels, and does relating to science comes from non-school experiences. Instead of school science affecting student behaviors in out-of-school settings, school science seems to have little relevance.

Attending to these lingering problems is an imperative. Surely their solution would bring a new school science--a kind of science that can be an effective force for producing the kind of world we want and must have.

A Supervision Perspective

LaMoine L. Motz
Oakland County Schools
Pontiac, Michigan

The general format for the 1982 Curriculum Update Conference provided participants with several opportunities each day to discuss the major presentations and to discuss what implications these presentations had for persons involved with the supervision of science.

Discussion sessions centered around such topics as decreasing instructional time in science. Time on task or engaged time is decreasing in science each year. More time is being devoted to the "basics" and less and less time to science, especially at the elementary and middle school grades. One participant reported that over the past sixteen years the amount of instructional time in schools is rapidly decreasing. Length of school day has diminished from as much as seven hours, to as little as five-hour school days. Students are now receiving two and one-half years less of schooling than their predecessors did fifteen years ago. Another problem supervisors were quick to point out was that of the reassigning of teachers at the elementary and secondary levels. Many science teachers are certified in their area, but are actually not qualified. Some have been reassigned from physical education, home economics, social studies to teaching science, but lack the confidence or have not kept up with a rapidly developed content in the biological and physical science fields. Thus, many reassigned science teachers are "certified," but not necessarily "qualified." There is a real lack of staff development programs being offered at the local district level to combat these problems. More training of reassigned teachers is needed in local school districts. Regional service centers need to offer more support for the science teachers, since monies for "hands-on science" seem to be decreasing. In summary, the following issues, problems, and needs were discussed during the conference

break-out sessions:

1. Need more engaged time for activity-based science. Instructional time is decreasing.
2. Reassigned teachers need in-service. Many science teachers now teaching have a limited background.
3. Declining enrollments in the secondary sciences, especially in the physical sciences.
4. Lack of effective-informative science staff development sessions for elementary and middle school teachers.
5. Social pressures confronting teachers, such as accountability.
6. Need more teaching with emphasis on science-based societal issues.
7. Need more support systems at regional or local level which provide materials to teach science.
8. Need more science supervisors-rapidly becoming an endangered or extinct species.
9. Need more school-based community support for local curriculum development. Lack of money and time are current problems.
10. Supervisors and teachers need to be more politically active--to have a good science program we need to "sell our product."
11. Need more emphasis on laboratory activities in both elementary and secondary science.

"Where are we going in science curriculum development" appears to be the key issue that teachers and supervisors face. Are we going to be reactive or proactive? This appears to be a major concern expressed by conference participants.

A Teaching Perspective

Carolyn Brockway
George Washington High School
Cedar Rapids, Iowa

The break-out sessions followed most of the major presentations at the Conference. The purpose was to discuss controversial issues brought out by the speaker. Each break-out session was fairly well attended, considering there were other things going on at the same time. They were attended by teachers, administrators, and students. Topics discussed ranged from the previous presentation to a wide variety of related topics. In all sessions, everyone in the group contributed to the discussion.

All these sessions were judged as very worthwhile. People from many different parts of the country had an opportunity to share problems and to get better acquainted with each other. Participants were eager to offer suggestions to others for solutions to their problems. These informal discussion sessions contributed to a one-ness among the participants; they are an important feature of a conference and should be a part of future ones.